tech engineering news

may 1952

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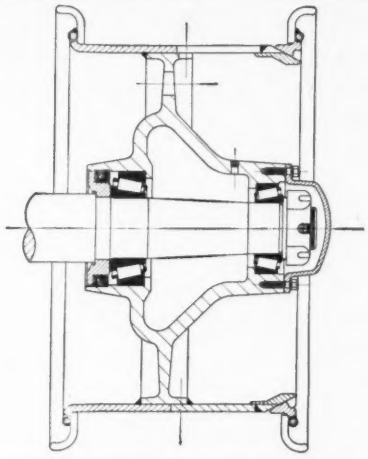

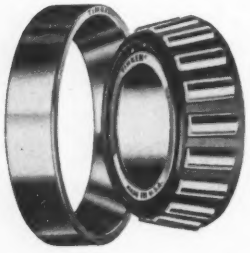

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See December 1951 issue of Fortune Magazine for description of new multimillion dollar GM Research and Technical Center in Detroit.

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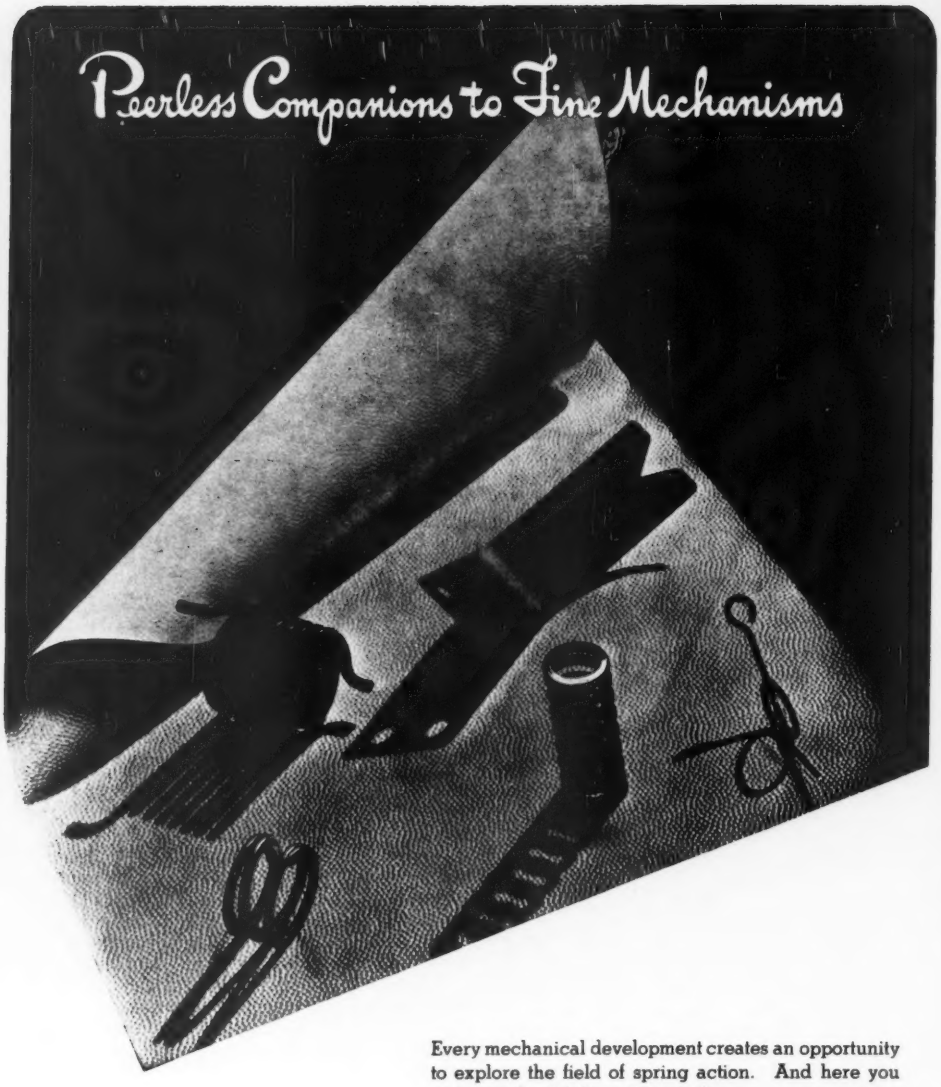

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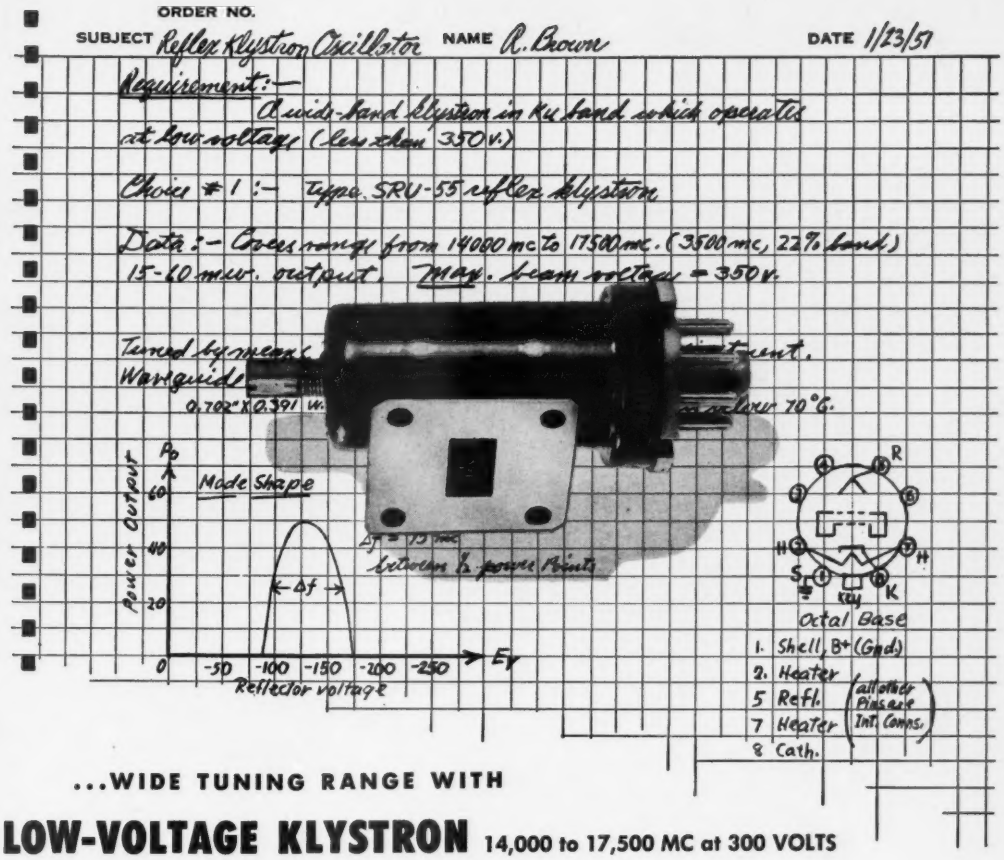
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FRONTISPIECE

M.I.T. Flight Simulator Duplicates Aircraft Flight Conditions

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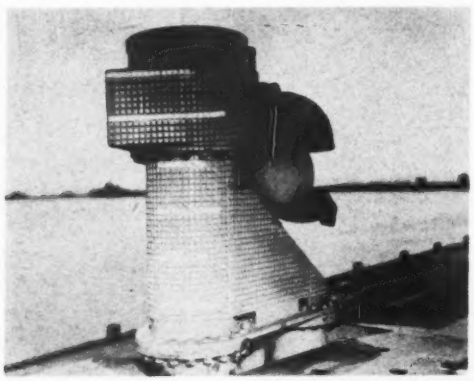
underwater killers

New Developments in Submarine Warfare

By Stanford R. Amstutz, '54

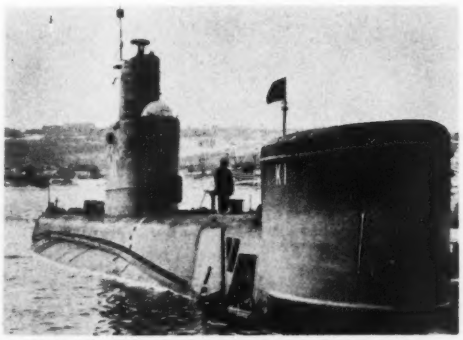
On April 11, 1900, the United States Navy purchased its first submarine — a small, seventy-four-ton craft designated at the time as a "submersible torpedo boat." This little vessel, which had but one tube from which to fire her three torpedoes, was the *USS Holland*, named for John Philip Holland, then principal American proponent of the submarine.

Since that time the submarine has undergone a continuous process of evolution until it reached a wartime peak around 1945. The backbone of our World War II submarine force, the fleet-type submarine, had little resemblance to its original predecessor. These fleet-type subs carried a crew of from sixty-six to seventy-eight, displaced over eighteen hundred tons, and were three hundred six feet long. However, since



The German type snorkel shown here has now been streamlined.

World War II, several new types of submarines have been created and added to our defensive forces. Most interesting of these is the SSK class which is popularly known as the "Killer" sub. More will be said of this model later. A new class of attack submarines, three of which have been launched within the past year, has come into existence. For the Guppy (greater underwater propulsion power — with a "y" for euphonious pronunciation) submarines the accent is on fire power, maneuverability and speed. Being snorkel equipped, they can travel faster beneath the surface than above it. Several other types new to the fleet are being built, converted, or are already in service. One of these is the Radar picket submarine, whose function is to give early warning of the approach of enemy planes or guided missiles. Another is the SSM series of mine-laying subs. A submarine of this type can creep into enemy harbors or sea lanes, spawn its lethal eggs, and escape undetected. We also have troop-carrying submarines, cargo-carrying submarines, and oiler submarines. Of the cargo-carrying subs little is known except that they could successfully be built much larger

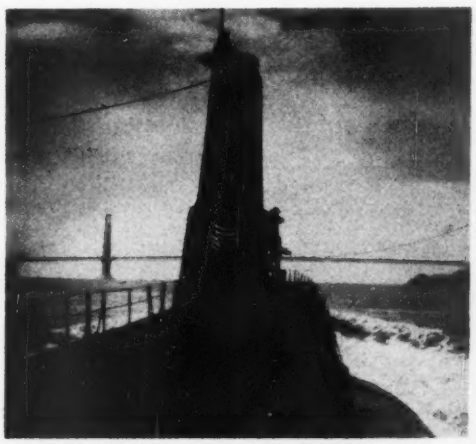


The bulging detection gear on the bow of this submarine makes her a deadly weapon.

than present-day offensive models. During the last war, the Japanese had three submarines built as underseas aircraft carriers but used mainly for cargo-carriers — that were four hundred feet long, had a forty-foot beam, and displaced fifty-seven hundred tons when surfaced. All three were more than twice the size of the biggest American submarine ever built: the *USS Argonaut*, twenty-seven hundred ten tons.

The submarine prior to World War II was not a submarine in the correct sense of the word. The numerous developments and improvements which had so changed the submarine from its prototype, the

(*Continued on page 16*)



This "sub oiler" can carry fuel to another submarine or to troops on shore.

south korea—aggressor

Poll of Italian Students Gives Startling Results

By the T.E.N. Staff

Polling arranged through Nereo Agostinelli, '54

There is a war right now in Europe and Asia. East and West are competing for the support of the countries that are within the Western sphere of influence but have a Communist faction of some strength. The security of the Western World depends to a great measure upon the strength and unity of the European nations that are bordering the Iron Curtain.

How successful has Communist propaganda been? One of the most susceptible groups to Red influence is the youth of a nation. The staff of the *Tech Engineering News* felt that a poll of Italian college students would give some indication of the future trends of Italian political thinking and a measure of how much we have swayed Italian youth to our side. Originally it was planned to poll several thousand students throughout Italy, but legal difficulties developed which made nation-wide polling impossible. However, last November a group of two hundred and fifty students of engineering, art, and medicine at the University of Genoa answered *T. E. N.* questionnaires. While this is a small fraction of the total Italian student body (slightly greater than one per cent), the results obtained at least have some significance.

The method of polling was simple: question sheets were distributed to freshmen and sophomores in physics lectures and Italian classes. The sheets were marked and returned unsigned. The questions asked in the poll roughly fell into four separate categories, as follows:

I. Questions About War

1. Is a World War inevitable?
Yes 197; No 38; Don't know 14.

2. Do you favor Italian participation in the Atlantic Pact?
Yes 54; No 189; Don't know 11.

3. Can Europe be defended from a Russian attack?
Yes 37; No 192; Don't know 20.

The strong feeling that another World War is inevitable must be very depressing for Italian youth, for they reveal great doubt of Italy's ability to withstand a Russian attack. Furthermore, almost exactly the same proportion of students were against Italian participation in the Atlantic Pact as doubted Europe's chances against Russia. The correlation is obvious; these students will be the very men to fight Russia if war comes. It would take a rare individual indeed to advocate participation in a pact which he feels might drag him into war. This reluctance of Europeans to link themselves with the United States militarily is best demonstrated by Western Germany but felt throughout Europe. As the NATO Army becomes stronger, sympathy towards the Atlantic Pact will probably grow. Our task is to impress Europeans that the unity achieved by the Pact will actually decrease the probability of war.

II. Questions About America

1. America is:

a. The land of materialism, where spiritual concepts are of secondary importance.
Yes 198; No 50; Don't know 2.

b. An imperialistic power menacing world peace.
Yes 175; No 40; Don't know 35.

c. A truly democratic nation.
Yes 102; No 100; Don't know 50.

d. Dominated by Wall Street.
Yes 150; No 50; Don't know 20.

e. Interested in maintaining world peace.
Yes 136; No 62; Don't know 43.

2. There is greater political liberty in Italy than in America.
Yes 199; No 40; Don't know 10.

3. Labor unions are stronger in Italy than in America.
Yes 53; No 145; Don't know 28.

4. Was South Korea the aggressor in June 1950?
Yes 137; No 28, Don't know 19.

These results were startling in many cases, and indicate that U. S. propaganda has largely failed to bring Italian youth to pro-American thinking. The most shocking and disappointing opinion is that South Korea was branded as the aggressor in June 1950 by a five to one ratio. This result, coupled with the four to one majority thinking that America is an imperialistic power menacing world peace, clearly indicates that we have completely failed to convince these Italian students of our integrity or honesty of purpose. The student majority evidently disbelieves our repeated statements about the origin of the South Korean conflict. If they could think South Korea the aggressor, they could believe that we would do anything that would gain us the slightest advantage. Perhaps it is difficult for us, with virtually all news sources informing us of North Korean aggression, to see how youth of approximately our same status in Italy could have such diametrically opposed views.

America is also thought by Italian students to be controlled by Wall Street banking interests, which is roughly the stereotyped Russian picture of us. Of course this opinion is also held by a considerable number of Americans and is not necessarily the result of communist influence. However, it does represent a lack of faith in the America which our State Department describes.

There is a superficial lack of agreement between the answers given to 1*b* and 1*e*, but the answers do not really conflict. We could be a menace to world peace while desiring to maintain it. In fact, Russia is probably interested in avoiding war as far as she herself is concerned. "Imperialistic" is the key word in Question 1*b*, and the students' opinion seems clearly defined.

(Continued on page 18)

Arrival of Scandinavian Students — June 1949.

Visiting at International Harvester Company, Chicago, Ill. — NAM Tour, September 1950

foreign student

A Survey of Four Years of Operation

Press release. Dateline: Monday, March 1, 1948, 12.01 p.m., Cambridge, Mass. The text: "Expanding an idea first conceived in the depths of a Cambridge subway tunnel, a group of students at the Massachusetts Institute of Technology are presently working on a plan whereby 80 European graduate students may come to MIT for study this summer. The Foreign Student Summer Project . . . is to be held for a three-month period during the summer session of MIT.

"[The students] desire to contribute their share to the peace of the world by working through what they believe to be the most common grounds of agreement throughout the world: the study of science and technology. [The participants] will be selected on a basis of leadership as well as scholarship.

". . . the MIT Corporation has voted to allow free tuition for the visiting students. . . . An additional $25,000 remains to be raised . . . to cover the cost of food, books, and transportation.

"Dr. Karl T. Compton, President of MIT, said, 'The objectives . . . are very praiseworthy.' Lord Inverchapel, British Ambassador to the United States, wrote, 'I feel great admiration . . . wish you the greatest success.' "

This is, by and large, the gist of the baptizing speech as it was written by the students of MIT, and seconded then and since then by many people who have kept the idea alive and have advanced it in the intervening years.

Square Dance at International Picnic — August 1948.

Behind FSSP (the full title of the Project soon proved to be too unwieldy for everyday usage) lay the conviction that students can and should, in their modest way, accept the challenge of improving international relations which suddenly came so much to the foreground after World War II. As a matter of fact, the Project was conceived two years before the advent of President Truman's "Bold New Program" for aid to underdeveloped areas. As one might be led to argue, the Project presents an unmistakable example of what we fondly call "private initiative."

What, then, is FSSP today, after four successful summers of operation and in the midst of preparations for the fifth one? First, Europe no longer has the monopoly of being the only continent to participate; in 1949, countries in Asia, Africa, and Oceania were added, and in 1952, for the first time, South America will be represented also, bringing the number of countries to approximately 35. Unlike 1948, when participants were invited to attend regular MIT courses, the present emphasis is on research, and all other studies (in the libraries or at lectures) are geared to provide the necessary background for this research.

The page titled "Purposes" of the official FSSP report for the Summer 1951 contains what may be taken as a crystallization of ideas over the past years:

"*To Advance Technology and Science.* To bring foreign engineers and scientists to MIT where they can pursue their work in modern laboratories, making con-

tacts with American technical personnel and observing techniques and equipment, and to show the applications of technology to industry.

"*To Promote International Friendship.* To establish a community of people of many nationalities and backgrounds learning from each other, becoming friends, and setting up the contact which will lead to greater interchange of ideas among nations.

"*To Better Foreign Understanding of America.* To give participants a clearer understanding of the United States, its institutions, its customs, its problems, and its beliefs."

But perhaps it is time now to introduce a few practical examples, taken at random over the past years:

An Indian scientist doing research on cheap water purification techniques towards the end of eliminating fluorosis, a condition which kills thousands in India every year.

A Dutch engineer is anxious to try out a bonding resin that he has developed to replace rivets in airplane construction. He lacks testing equipment in his own country. A similar method was used in the United States in the tail section of B-29s, but results were not too satisfactory. So this man comes over and gets a chance to use the testing equipment he dreamed of. People here take a good look at his resin and they like it. Everybody is happy.

A chemist from Turkey comes over to develop a process by which sulfuric acid, basic to many industries, may be manufactured out of existing resources in Turkey. He works part-time as guest of Monsanto Chemical in Boston.

A Frenchman, microwave-equipment specialist, studies traveling wave tubes at MIT; soon the Raytheon Corp. of Waltham, Mass. spots him and invites him to stay on for a while after the summer is over. They have him make transatlantic calls to his laboratory in Paris to check up on some of the details.

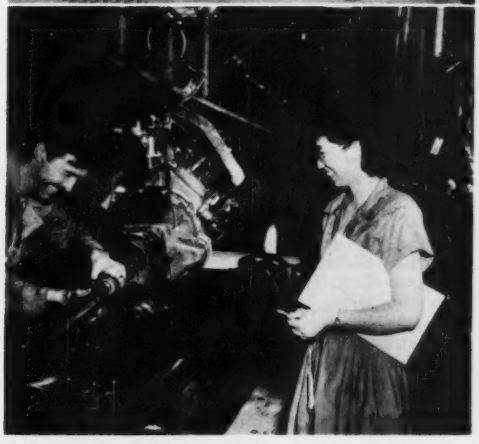
A German physicist, while at MIT, develops new photographic techniques for use in obtaining and analyzing results of investigations with synchrotrons

(*Continued on page 20*)

summer project

By Rudolph E. Kalman, '53

FSSP Participants Welcomed in Washington, D. C., by Edward W. Barrett, U. S. Assistant Secretary of State for Public Affairs — September 1950.



Campus Tour at MIT (Entrance to Eastman Laboratory) — June 1948.

Plant Visit at the Ford Motor Company in Somerville, Mass. — July 1949.

living backwards

The Time Travel Theme in Science Fiction

By Rudolph William Preisendorfer, '52

" '*Living backwards!*' *Alice repeated in great astonishment. 'I never heard of such a thing!*"
" '*— but there's one great advantage in it, that one's memory works both ways.*' . . ."

"Grant me the possibility of some means to travel into the past and future," asks the Science Fiction writer, "and I will tell you a thousand tales." And to date, a thousand and more tales have been told.

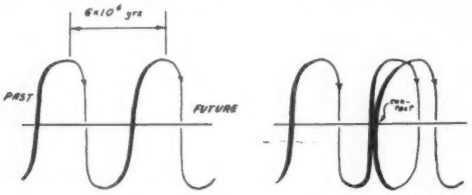


Figure 1. Illustrating the hypothesis from *Sands of Time*

The Time Travel theme in Science Fiction is woven solidly into SF's past development. In the early, immature years of the field (about the late twenties and early thirties of this century) this immaturity was reflected in the plots of stories using this fascinating theme. The simple and most immediate effects achieved in a temporal displacement were naively explored in such stories as: *The Time Bender* (Oliver Saari; August '37),* *The Time Contractor* (Eando Binder; December

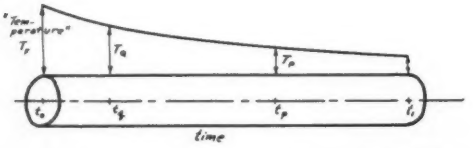


Figure 2. Illustrating the hypothesis from *The Liners of Time.*

'37), *The Time Accelerator* (July '36; A. Macfadyen), and somewhat earlier: "*Tourmaline's Time Cheques* (by C. Anstey, D. A. Appleton and Co., 1891). In the latter story, our hero, Tourmaline, rents out snatches of spare time for his customers' consumption.

The privilege granted the author of roaming about an infinitely extending temporal backdrop went to his brain and left him intoxicated with the richness of the possibilities. *The Time Imposter* (Nat Schachner; March '34) wrestled with the possibility of going back into the past and attempting to preserve the life of genius. *Time Haven* (H. W. Graham, Ph.D.; September '34) considered the possibility of accruing a fortune by depositing real estate and money and then going ahead to clean up in the remote future. Later on, the writers started to cast around for working models for time machines and working hypotheses for time travel. Some very interesting concepts have been given us by these more searching writers. In *Sands of Time* (P. Schuyler Miller; April '37) and in his later *Coils of Time* (March '39), the concept of time being like a huge helix embedded in a four-dimensional matrix of space-time was developed and used as an important, integral portion of the plots. Miller hypothesized that the world-line of the universe was like a spiral. The "pitch" of the spiral was six million years. Hence in normal time the universe took six million years to travel along the curve of the helix, an angular distance of 2π radians. The scientist in the story (an archaeologically oriented physicist) develops a machine that "electromagnetically compresses" the helix of time so that two adjacent portions of the coil are in contact, whereupon he bridges the time gap to the next coil and

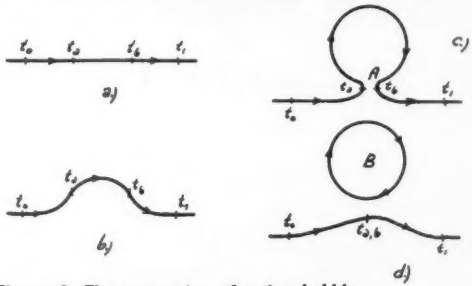


Figure 3. The generation of a *time bubble.*

moves six million years into the past or the future. This is the only possible single time jump. The time machine allows only jumps into the past and future of multiples of six million years . . . not too much selectivity.

A fascinating analogy with time travel was developed in Fearn's book, *The Liners of Time* (The World's Work Ltd., London, 1913). Fearn's time dimension was likened to an infinitely long bar of material which had a decreasing temperature distribution along its length. Fearn's universe moved along the bar from hot to cooler regions. The universe "cooled off" at a given, unalterable rate, thereby moving with a determined rate through time (along the bar) so that its temperature was always the same as the bar's. Fearn had his characters time travel by making a machine which would change the "temperature" of its contents and thereby precipitate the machine and contents to that portion of the universe's time track where the temperatures matched. Thus to go into the future, Fearn's machine was made to "cool" the contents, and to travel to the past, the contents had to be raised in "temperature."

(*Continued on page 26*)

*These dates refer to the issues of *Astounding Science Fiction* (published by Street and Smith, New York) unless otherwise noted.

quantum mechanics, causality and free-will

By Arnold Levine, '53

It is with an air of justified superiority that we look back into history and consider the attitudes of those who fought the innovating ideas brought about by scientific research. However, when we note the incredulity and hostility which has greeted such notions as the variability of time with velocity, the existence of zero or negative mass particles, and the curvature of space, we are justified in a little skepticism as to whether we have really outgrown the attitudes of the past. Of course, the loudness of denunciation has subsided over the centuries from an hysterical roar to a disconsolate murmur. Nevertheless, because the acoustics of criticism have changed, this is no implication that we are now more willing to accept new doctrines. What has changed is our method of rejection. Today, one does not cry out against new ideas, one ignores them. So what, we ask, if our conception of causality fails in the realm of atomic physics? This concept is applicable to our everyday life and that is good enough for us.

But is this attitude justified? Such is the inertia, the difficulty of emotional adjustment to new ideas, that little has been done in determining how much these ideas affect us, or how philosophers might apply them to human affairs. That philosophical applications have proven to be more than the trivial ramblings of old men with nothing better to do is obvious when we note the social and intellectual revolutions produced by Descartes, Huxley, Locke, Hegel, Marx, and others; men who validated arguments according to their success in science, and who applied as their thesis the underlying implication of science — the existence of a rational scheme of the universe. If we are to discover the importance of the brilliant discoveries of the last half century, we must abandon our position of rejection and begin to replace the weakened conceptual props of classical philosophy by a new and revitalized structure. It appears that the improved construction should develop its framework from the ideas of quantum mechanics, for it is here that causation, the concept upon which classical philosophers built their systems, is found wanting and replaced. In order to demonstrate such a development, I will first show how quantum mechanics has brought the idea of causation into disrepute; from there, new concepts will be applied to the age-old question of free will, and the formulation of a new political philosophy will be indicated.

As a starting point, we consider our pictorial representation of events. We have developed only two ways of representing motion; as moving particles or waves. Overwhelming experimental proof had shown that the electron is a particle. However, in 1925 Davisson and Germer conducted experiments which made Ph.D.'s fog their glasses in excitement, and caused scientists to defend or denounce old ideas from the pulpits of their lecture halls. They had found that the electron also behaves like a wave. This fact produced contradictions in thought, for the particle and wave notions involve completely different conceptions. A particle has the property of being uniquely determined in space, while a wave has indefinite extension as it spreads out. To settle this enigma of the electron, and similar problems, De Broglie and Schrödinger developed the ideas, later corroborated by experiment, that our pictorial representations are not applicable in certain cases, and that particles, even macroscopic bodies, sometimes behave like waves. With the formulation of Heisenberg's "Uncertainty Principle," a name which, indeed, represented the feeling of scientists toward it, there developed over the years an understanding of the problem. Heisenberg showed that the trouble lay in the fact that it was impossible to simultaneously determine the position and velocity of an electron. Any device, no matter how it is constructed, or how sensitive it is, must affect the position and velocity of the particle, thereby invalidating measurements upon it. For instance, to determine the position of an electron, we might use an optical system, bouncing light off the electron and observing the scattered light. It is known that the shorter the wave length we use, the greater will be the exactness of the measurement. However, Compton has shown that high frequency light acts like an energized particle. Thus, when the light hits the electron, there will be collision and recoil. The direction and size of the recoil is indeterminate, thus invalidating our measurement. Furthermore, Heisenberg has shown that the more accurately we measure the position of the electron, the greater is the inaccuracy attached to any measurement of its velocity.

Still, one might well ask whether or not we could describe the motion of an electron if we knew all the forces acting upon it. For instance, could we not predict the direction and magnitude of the electrons velocity after it has hit a known potential barrier? The answer is no. Because of the wave nature of the particle, it could be transmitted or reflected, as is light by glass. We can only assign a probability to its actions, no matter how well we know the forces acting upon it.

How do these observations come into conflict with the classical ideas of causality? Classically, the concept of causation is an expression of experience. That a certain sequence of events has occurred and recurred in the past, and that, without interference, will occur in the same way in the future, is the verbalization of this concept. Thus, the more repeated an experience, the more readily can we assign causality to the sequence of events. Therefore, we are capable of predicting events on the basis of past experience. Yet quantum theory has shown that we cannot predict what a particular electron will do, no matter how great our experience. Similar experiences in other parts of science, led Max Planck to say, "Even if we choose ever so simple conditions, and use ever so delicate measuring instruments, we shall never succeed in calculating in advance the results of our measurements with reasonable accuracy; that is to say, not so accurately that it will agree with the measured number to the last place. . . . Our experiences, therefore, compel us to recognize the following statement as a given and established fact. In not a single instance is it possible to predict a physical event exactly." Thus, causation finds itself in disrepute because, contrary to its underlying impli-

(*Continued on page 32*)

future uses of solar energy

By Dr. Maria Telkes

Research Associate in the Department of Metallurgy

From the *Bulletin of Atomic Scientists*

Solar energy may be evaluated in terms of atomic energy, by comparing the theoretical energy equivalent of the fissionable material with that of solar energy received on the earth's surface. The heating value of 1,500 tons of coal is equivalent to one pound of U-235 representing 3×10^{10} Btu. In the temperate zone on a clear day 2,000 Btu is received from the sun by one square foot horizontal surface during the summer, or 5.5×10^{10} Btu per square mile. One pound of U-235 is therefore nearly equal to the amount of solar energy received on a half square mile on a clear summer day. The above comparison does not take into account the efficiency of converting either energy form into useful energy.

Solar energy has been evaluated recently in terms of fuel values, technical uses, and human needs by Daniels, Ayres, Daniels, Hubbert, and Wigner. Solar energy received by the land area of the United States is 2,000 times greater than the total fuel consumption, without comparing the efficiency of conversion of either energy form.

The amount and distribution of solar energy in the United States are well known. The Weather Bureau records contain adequate statistics. Solar energy can be expressed in various units:

Energy units per (square foot hour)	*One hour of clear sunshine around noon, at optimum incidence near sea level*
Btu	330
Kg.cal	83
Watt-hour	97
Foot-pounds	255,000
HP-hours	0.13

One hour of clear sunshine on one square foot, as specified above, is comparable to:
Wind — 27 miles per hour on one sq. ft. for an hour;
Water falling 100 feet — 300 gallons;
Manufactured gas — ½ cubic foot;
Coal — 0.03 pound.

According to the Weather Bureau statistics, one square foot of horizontal surface receives in an average year the amounts of solar energy expressed in the following table in equivalents of pounds of coal and cost of the latter (assuming that one pound of coal produces 10,000 Btu, and one ton costs $10.00).

Location	*Solar Energy Btu / square ft. year*	*Coal lbs.*	*Cost of coal dollars*
Honolulu, Puerto Rico	800,000	80	$0.40
S. California, New Mexico, Arizona	550,000–700,000	55–70	0.27–0.35
Washington	450,000	45	0.225
New York	400,000	40	0.20

The use of solar energy depends upon its conversion into useful energy forms. The theoretical principles and limitations of such energy conversions are well known.

The amount of solar energy that can be collected depends upon the effective area of the collector, and the possibility of placing it so as to receive the maximum amount of sunshine during the major part of the time cycle of its use. The design of the solar energy collector is not an easy task, because account must be taken of the diurnal and seasonal changes in the position of the sun in the sky, and its construction costs are limited by economic considerations.

The efficiency of solar energy collection, that is, the percentage of the incident solar energy convertible into useful energy is limited by certain unavoidable losses. Devices in which solar energy is converted into *heat*, and utilized as such without further conversion to mechanical or electrical energy, can attain considerable efficiency. Examples of this type are the solar water heaters used in semi-tropical regions. Their efficiency may be as high as 50 to 80 per cent on clear days, depending upon the amount of sunshine, the temperature of the water, and the skill of the designer.

"One of the first solar engines."

Described by Hero of Alexandria (B.C. . . . .). The diagram shows how the statue produced musical sounds. The pedestal was hollow, containing water with air space (F) heated by the sun. The expanding air pressed water through tube (B) into compartment (C), expelling air from it through the pipes. When the pedestal was shaded, fresh water entered through (A) from well.

Solar heating of houses, recently carried out around Boston and elsewhere, indicated that winter sunshine can be usefully collected with an efficiency of 35 to 40 per cent. The collected sunshine may be stored in water, or as the heat of fusion of low-cost chemical compounds. On clear winter days, 50 to 60 per cent of the incident solar energy can be collected. It should be remembered that the average efficiency of the coal furnace used for house heating is around 50 per cent and the first solar heated houses nearly approach this efficiency.

For thousands of years the human races shivered in the winter (many still do) using wood-burning fireplaces or stoves, with an efficiency of 5 to 10 per cent. Considerable research and development were needed to produce the highly efficient furnaces of today. Further research and development work on the solar heating of houses should similarly improve their efficiency and diminish the costs.

It is possible to combine solar house heating with summer cooling to provide additional comfort. For this purpose, solar heating may be combined with the Heat Pump.

Another solar heat-transfer application of high efficiency is the *solar*

distiller. Tropical arid islands could receive sufficient potable water, by distilling sea water, using the over-abundant sunshine for this purpose. The efficiency of this process is around 60 to 70 per cent in the tropics. Development work on solar stills for life rafts led to their use during the last war. Further development work is needed, before large-scale solar sea water distillation will be economically feasible. The by-product — sea salt — also may be valuable. Around 700,000 tons of "solar salt" are produced yearly by open evaporators, mostly in the region of San Francisco. The economy of arid tropical or sub-tropical regions may be improved considerably by large-scale solar distillation combined with by-product use.

Courtesy of the Smithsonian Institution

Dr. C. G. Abbot's model solar steam turbine is shown at the Smithsonian Institution.

"Solar engines," in which solar energy, collected as heat, is then used to produce electrical or mechanical energy, are limited in efficiency by the second law of thermodynamics, in the same way as fuel-operated engines. This law determines that the efficiency of a heat engine is the higher the larger the temperature difference available to operate the engine. The high temperature level needed for efficient operation can be attained, in the case of solar engines, only by concentrating the radiation falling upon a comparatively large area, on a relatively small heat transfer body. Means of concentration (lenses, parabolic reflectors) must be accurately focused and their construction is rather intricate and expensive. The largest *solar steam engine*, built by Shuman in Egypt, had an efficiency less than 5 per cent. The *solar steam turbine* of Dr. C. G. Abbot had a calculated efficiency of 15 per cent. The efficiency is not mentioned in the meager reports available on the recent experiments at the only existing Solar Power Institute located in Tashkent, in Soviet Central Asia.

With improved materials for *thermoelectric generators*, an efficiency of about 5 per cent appears feasible in the conversion of solar energy into electrical energy by the

This solar distiller built at Cohasset, Mass., produced 44 gallons of fresh water daily and occupied an area of 200 square feet. It was designed for tropical islands.

heating of one junction of a thermoelectric couple. At the same time, a much higher proportion of absorbed solar energy can be recovered as heat at a moderate temperature level, and utilized for house heating purposes.

An entirely different type of solar energy converters can be based on photovoltaic, or photogalvanic cells, in which light energy is transferred into electrical energy without preliminary conversion into heat, and which are therefore not limited by the second law of thermodynamics. Although considerable research and development work has been carried out with *photoelectric cells* for signaling and communication purposes, not much progress has been achieved in increasing their efficiency as energy converters. Even if inherent difficulties could be eliminated, the efficiency of the presently known types of these cells is probably not much above 0.1 per cent. (*Continued on page 40*)

Sun-heated house in Dover, Mass. Heat from the sun is stored as the heat of fusion of chemical compounds.

calculus by machine

The Story of Analog Computers

By J. R. Schrieffer, '53

Many problems arise in modern research which are describable in terms of differential equations. The solution of these equations is often too arduous or too complex for ordinary analytical treatment. The field of mechanical and electronic computers has therefore been of great service. Because of the physical limitations of such devices, one must sacrifice either a degree of accuracy, speed of computation, or flexibility of operation. Such limitations divide the type of computers into two broad classes, the digital computer and the analog computer. The digital form operates on discrete values, such as the common integers which are combined to form a given number. The analog form, however, operates on continuous variables such as $x = f(t)$. The operations carried out depend upon the particular computer in question. This article will for the most part deal with the analog computer of the electronic variety.

The electronic analog computer uses voltages to represent dependent variables with real time being the independent variable. The output is repetitive and the length of time required to obtain one solution is the computing cycle. As time is the independent variable, one must choose an interval of this variable because a solution for all time cannot be obtained in a finite computing cycle.

The computer basically consists of an input section, a computation section, and an output section. The input allows arbitrary functions to be introduced to the computation section and has equipment to set up a given problem (programming circuits). The central portion of the computer is made up of units which generate arbitrary functions of time. The output provides means for reading information out of the computer.

There are in general two distinct manners in which the computer may be used. First, it can simply perform a series of operations on a function and explicitly display the result. This may be illustrated by computing the Laplace Transform of the function $f(t)$.

$$F(t) = \int_0^\infty e^{-pt} f(t)\,dt \qquad (1)$$

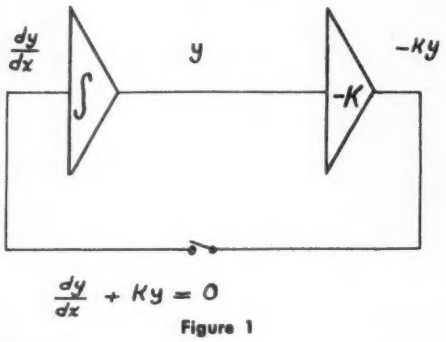


Figure 1

In this instance, the problem is programmed by introducing $f(t)$ and e^{-pt} into the computer, multiplying them and integrating them from zero to infinity. The second manner of operation is to form a computing loop by feeding a portion of the output into the input, simulating the condition of satisfying an equality in an equation. This may be illustrated by the solution of the equation:

$$\frac{dy}{dt} = -ky \qquad (2)$$

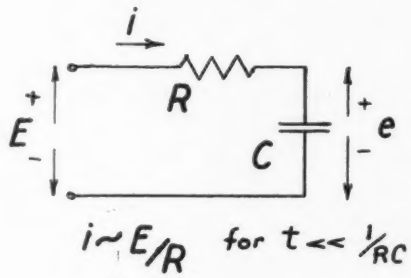


Figure 2

In order to solve (2), it is desirable to rewrite it in the following form:

$$\frac{dy}{dt} = -k\int_0^\infty \frac{dy}{dt}\,dt \qquad (3)$$

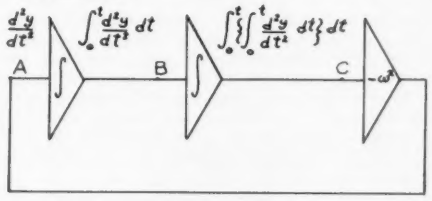
This form eliminates the necessity of differentiation, a very difficult electronic task. The operations involved are integration and multiplication by a negative constant. See Figure 1. The equality is imposed by feeding the result of the above operation into the input of the integrator, thus making their difference zero. The limits of integration are provided by clamping the output of the integrator to zero at the beginning of each computing cycle and adding a d.c. voltage to the output of the integrator determining the initial value of the integral. Similarly, the initial value of the derivative may be determined by adding a d.c. voltage to the output of the coefficient box. The solution is obtained by observing the output of the integrator, as this is just the value of y as a function of time. This general method of solution will serve as a guide to solutions of more complicated problems with which we will be concerned.

Before continuing with the functional description of the computer, a look at the method of computation in the operational units is useful. The adders usually consist of two vacuum tubes in parallel, fed by a common load. The output of the combination is proportional to the sum of the voltages applied to the two grids. The coefficients are merely linear amplifiers

with variable gain. The operation of the above units are:

$$y_{out} = y_{1_{in}} + y_{2_{in}} + y_{3_{in}} + \ldots . \qquad (4)$$
$$y_{out} = Cy_{in}$$

respectively.



$$\frac{d^2y}{dt^2} + K\frac{dy}{dt} + \omega^2 y = 0 \quad ; \quad K = 0$$

Figure 3

The integrator in its simplest form is a series *R-C* circuit. It may be seen from Figure 2, for large values of *C*, the current through the circuit will be $i = E/R$, for small values of *t*. But we know for a capacitor, $e = \frac{1}{C}\int_0^t i\,dt + e_0$. Thus, from the above relations:

$$e = \frac{1}{RC}\int_0^t E\,dt + e_0 \qquad (5)$$

Thus the output voltage is essentially the integral of the input voltage, if the integration time is small compared to the time constant of the circuit.

Up to the present time, electronic multiplication has been relatively inaccurate. Many methods depend upon tube non-linearities, which vary with tube life and external conditions. However, the "quarter square" method has been used with some success. If the product *xy* is to be formed the following operations are carried out:

$$xy = \frac{1}{4}[(x+y)^2 - (x-y)]^2 \qquad (6)$$

The squaring operations are performed by curve tracers, a device described below. The other operations are carried out by the conventional units already described. When a second pair of curve tracers are used to introduce correction terms, accuracies of the order of 0.2 per cent over a 70-db range are obtainable.

The curve tracer consists of a cathode ray tube which has a mask cut to the shape of the desired function covering its screen. A photoelectric cell is placed in front of the screen and variations in light intensity cause a voltage to be fed back to the deflecting plates, correcting the error in electron beam position. The voltage variation on the deflection plates is thus proportional to the change in height of the mask covering the screen. To form a square of a function, one merely places a parabolic mask on the screen and applies the function to be squared on one set of deflection plates, the resultant voltage across the perpendicular set of plates being the desired square.

The classical problem of the vibrating mass suspended by a spring is represented by the differential equation:

$$\frac{d^2y}{dt^2} + \omega^2 y = 0 \qquad (7)$$

Following the procedure outlined above, this equation is rewritten in the following form:

$$\frac{d^2y}{dt^2} = -\omega^2\int_0^t\int_0^t \frac{d^2y}{dt^2}\,dtdt \qquad (8)$$

The component set up is shown in Figure 3. As before, initial conditions are established by inserting d.c. voltages at *A*, *B*, and *C*. The figure is self-explanatory. The problem is readily modified to include damping effects by adding a term proportional to $\frac{dy}{dt}$. The equation now takes the form:

$$\frac{d^2y}{dt^2} + k\frac{dy}{dt} + \omega^2 y = 0 \qquad (9)$$

and transforming:

$$\frac{d^2y}{dt^2} = -k\int_0^t \frac{d^2y}{dt^2}\,dt - \omega^2\int_0^t\int_0^t \frac{d^2y}{dt^2}\,dtdt \qquad (10)$$

These equations have been written without considering forces on the system. The usual analysis of this problem consists of investigating the response just after a sudden stimulus has been applied. This condition may be imposed by adding a forcing function to the right-hand side of the equation. Such a function may be derived from a graph in the form of a mask on the curve tracer, or it may be represented by a function generator which approximates the desired function by specifying the constants of an nth degree polynomial. The solution will in general consist of two parts, the "steady state" response which will be present long after the stimulus is applied, and the "transient" response which will initially be present to satisfy the initial conditions. If the system is dynamically stable, the transient portion will decay to zero; if it is unstable, this response will become the dominating term in the solution.

Thus far, the problems considered have been of an elementary nature and could be treated analytically. Of course, in most physical situations nonlinear terms are present; springs are not simply described by a single constant, nor viscous forces by velocity constants. In these cases, analytical solutions are extremely difficult if not impossible to obtain. Here is where the value of the electronic analog computer lies. The coefficients of the terms in the equation may be arbitrary variables which are only available in graphical form, possibly from experimental data. This information may be introduced in continuous form such that the solution of the equation can be studied for varying conditions.

Another class of problems of considerable importance is that of determining the characteristic values of a parameter in a differential equation, given a set of boundary conditions. This might physically correspond to finding the normal modes of oscillation of a vibrating column or a vibrating string. The illustration used is that of a string of density ρ being rotated along its axis at an angular frequency ω. It may be easily

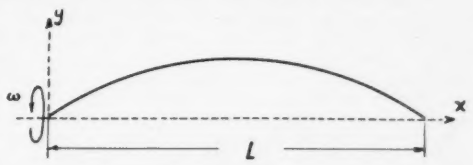


Figure 4

(*Continued on page 44*)

underwater killers

(*Continued from page 6*)

USS Holland, in all cases had not altered the fact that the "submarine" was still essentially a surface craft which could be submerged for short periods of time. These periods of submersion were of necessity relatively very brief. The submarine still relied chiefly on her diesels for propulsion and depended on her battery-powered motors when submerged. The exhaust gases and even more important, the tremendous air consumption of the diesels prohibited their use when beneath the surface, and so the time that a submarine could stay down was limited by the endurance of her crew and the longevity of her batteries. These two factors confined the period of constant submersion to about twenty-four hours.

Out of World War II came a device originally developed by the Dutch, and quickly adopted by the Germans which greatly altered the above-mentioned limitations, which had so hindered the submarine ever since its inception. The snorkel, for so it was abbreviated in the American vernacular, consisted of nothing more than a series of pipe-like breathing tubes which extended up about as far as the periscope. This enabled the submarine to remain below the surface for protracted periods of time and also to run while submerged on her diesels. The latter in itself was a great advantage since a sub's speed is much greater when propelled by the oil burning engines than by the electric motors. The snorkel had a valve device on its top which automatically closed when a heavy wave hit it and in this manner prevented sea water from coming down the tubes. Thus, with the advent of the snorkel, submarine warfare was drastically changed. The sub was no longer forced to surface every night to recharge batteries and refresh its internal atmosphere. Now the sub could stay down for long periods of time and travel for considerable distances while submerged. For example, the *USS Pickerel* recently traveled fifty-two hundred completely submerged miles in five hundred five hours, this accomplishment due almost completely to the snorkel. Submarine detection became tremendously more difficult.

There is, however, under development now a mode of propulsion which in one cataclysmic change promises to supersede the diesel engine and the snorkel. This is the power plant having as its basic component a nuclear reactor. Apparently, controlled nuclear reactions suitable for submarine propulsion are feasible today. In September of 1951 a contract was let to the Electric Boat Company to begin construction of the first SSN (submarine-nuclear) class submarine. Just how the reactor will operate is, for the public, principally conjecture. However, in one type of reactor, the huge quantities of heat given off during atomic fission are absorbed by a liquid metal which is employed in generating steam. The steam is fed into a turbine which either drives the propellers directly or indirectly by means of a turbo-electric system. As now conceived, the fuel for the atomic engine will be Uranium, which contains enough energy, as an AEC official pointed out, "to drive a ship tens of thousands of miles on one single charge of the reactor." Presumably the size of the atomic sub would be larger than the present-day average of eighteen hundred tons. In order to compensate for the extra weight of the reactor and especially the heavy lead shielding which must completely surround the reactor, the sub's hull was made fatter than the old fleet-type submarines. It will probably be able to cruise at twenty-five knots under water with a top speed of thirty to thirty-five knots in an emergency. It will carry no deck guns, have a knife-narrow deck. Another interesting feature is the control device to be incorporated, by means of which the sub, in her fast underwater runs, will be equipped with an airplane-type joy stick and will be "flown" like an airplane by the skipper or by the diving officer. The joy stick will control the bow and stern diving planes and the rudder.

The advantages of atomic powered vessels are obvious. The submarine could truly become a vessel correctly designated as a surfaceable underwater craft. The time it could stay down would be limited only by the endurance of the crew (oxygen bottles are to be carried to replenish the air supply). And as mentioned above, the range would be increased by a fabulous amount.

Torpedoes have been a principal weapon of the submarine ever since the sub's development. In fact, the *USS Holland* was designed with the objective of serving as a launching platform for torpedoes. Torpedoes themselves have a rather interesting history. They first seem to have appeared on the scene about 1585 in the form of "small vessels" each of which carried a quantity of gunpowder. These "infernal machines" as the people of that day called them were exploded by a clockwork mechanism. In 1730, the French scientist Desaguliers experimented with rocket-type torpedoes which were fired underwater and were said to have destroyed several boats. In 1801 at Brest, France, Robert Fulton destroyed a small vessel with a submarine mine containing twenty pounds of gunpowder, also set off by a clockwork device. The first torpedo of modern appearance was developed in 1866 by Mr. Whitehead, an Englishman. It was self-contained, and was driven at a speed of seven knots by a little reciprocating piston-type compressed-air engine. For many years most U. S. Navy torpedoes have been powered by a turbine-type "air-steam" engine in which compressed air and steam produced by an alcohol fire kick the turbine around. The most recent type of torpedo power is electricity provided by storage batteries. A now obsolete model of the electric-powered torpedo which came out in 1917 could travel approximately thirty-five hundred yards with a speed of twenty-seven knots. Today's electric torpedo is patterned after the German model. The electric's main advantage lies in the fact that there is no tell-tale exhaust trail. In 1945 almost two-thirds of all torpedoes fired by the Navy were electric. Most of the various torpedoes have a horizontal steering device centered about a gyro. Depth is governed by a depth engine which receives orders from a hydrostatic diaphragm and a pendulum. Warheads of World War II torpedoes carried four hundred to eight hundred pounds of TNT or torpex; they traveled at speeds up to forty-five knots and to distances of several miles. The latest in torpedoes, however, is the homing torpedo — electronically controlled, with sonar mounted in its nose. It starts out in the general direction of the target, but when it gets near enough for its sonar to hear the dull roar of the target's screws, it veers headlong toward the unfortunate ship. Should it miss on its first try, it curls relentlessly around to strike again, and if necessary, again.

Another potential submarine weapon of terrifying destructive power is the submarine launched guided missile. The vision of landing a V-1 buzz bomb on New York City intrigued the Germans for a long time. They eventually abandoned the proposed plan even though it did promise a tremendous, double moral

(*Continued on page 18*)

from the editor's notebook

Italian Poll.....

The results of our poll of Italian students were so unusual we felt it would be advisable to submit them to the analysis of a faculty member. **Professor George de Santillana** of the M. I. T. English and History Department, whose comments appear below, is well qualified for the job. He has maintained close contact with opinion in Italy, and spent some time in the country last summer.

This poll may look rather frightening. In fact, it is.

There may be slight distorting factors in the answers — not least, an impish desire to aggravate, and if possible to shock, for this once that Italians are asked something by Americans instead of being *told*.

Nonetheless, this is it. And it is not a Communist-line answer, as was to be expected, because Communists are much weaker in the universities than among the general population. What is shown here, rather, is the new Fascist-Populist trend which has been steadily gaining ground: a violent emotional release which combines realism with naivete, inside a good amount of confusion.

However, the answer is not so confused as it looks. It shows, e.g., a striking change over more than a year on the Korean question. In 1950, no one except a Communist would have answered that the South Koreans were the aggressors. After more than a year of varied military events, and the continued deafening clamor of the China Lobby, the isolationists and the witch-hunters here, it looks to the outside as if the Americans considered China as a piece of American property lost through accident or betrayal, and the Korean incident becomes in foreign eyes a first move to recapture it which miscarried, again through failure of the puppet regime.

Another indication is the growth of European isolationism and neutralism. It is the natural reaction to circumstances beyond their control. War has ceased to make sense for Europeans; it is like a hurricane, and they only hope it will be deflected to some other region. Hence a tendency to talk turkey with Russia, which of the two contestants appears less trigger-happy and more realistic.

The auspicious arrival of General Ridgway, author of Operations "Cleaver," "Killer," "Cutthroat" and "Strangler," is not apt to change their views on the subject.

As indicated repeatedly, these young men consider that Communism is here to stay, and also increase. The split on question 4 means that although they are anti-Russian, they consider the future is for the planned dictated economy and not for individualism. A nation with four million unemployed or more (ten per cent of the population) could hardly answer otherwise.

America is both "imperialist" and "democratic," because for most of these people democracy means "Wall Street bankers." In their view, it threatens world peace without really wanting to, because it lacks a consistent policy.

However, we may see that labor unions are still considered more powerful in the U. S. than in Europe, because it is common knowledge in Europe that unions there have been reduced to near-impotence by the conservative U. S.-sponsored government. If political freedom is felt to be greater nonetheless in Italy, it is because of the American crackdown on every kind of Leftist, which has no parallel in Europe.

An important further indication is that these students almost all believe in the forward march of the industrial revolution and of prosperity for the greater number, but that they do not associate this idea with America any longer. Prosperity, they think, will not change the feelings of the workers. In other words, economic progress is no barrier against world revolution.

It would be futile to say that all this means the failure of American propaganda. Propaganda is not an important political factor, and ours has never existed anyway in any useful sense. What it represents is the breakdown of American foreign policy, which is a well-known fact to most competent observers.

underwater killers

(*Continued from page 16*)

effect — good for the Germans at home, and bad for the Americans. We, however, in March of 1947 on board the submarine *USS Cusk* (SSG 348) did perform a successful guided missile launching from the deck of a submarine. The twenty-seven-foot "Loon," developed from the German V-1 buzz bomb, shot off from the specially constructed ramp, climbed skyward, and at a preset height, leveled off. Inside the *Cusk*'s control tower, the officer commanded the "Loon" to dip, move right or left, swerve, etc. At some seventy miles from the *Cusk* an automatic mechanism caused it to dive into the sea. Thus the guided missile truly promises to be a deadly weapon. Little is known about the recent developments in this field except that they can now be shot from submerged craft. We can envision an attack of the future against a principal seaboard city of a belligerent nation. An atomic powered submarine could approach within a few miles of the shore without having once surfaced, dispatch the missile, guide it home electronically, and be gone with the besieged city still knowing nothing of its whereabouts.

Recent developments are not, however, wholly confined to offensive weapons. A completely new type of sub has been developed which has been designated the SSK type. It is specifically designed to be an anti-submarine submarine. Three of these vessels, the K-1, K-2, and K-3, have already been commissioned. They are considerably smaller than the fleet-type sub, being only about one hundred ninety-five feet long and displacing seven hundred fifty tons. Their most distinguishing characteristic is a bulging bubble on their prow which contains sound detection gear of the most recent sort. Rear Admiral C. B. Momsen, director of underseas warfare, says, "I can say that no foe strikes more terror in the heart of a submariner than another submarine. It is somewhat analogous to two blindfolded antagonists armed with baseball bats waiting for the other to break the silence." The Killer sub's main weapon against her under-sea adversary will be the electronic homing torpedo mentioned above. It is expected to carry a crew of forty men.

Submarines had a somewhat spectacular record in the last war, sinking more than five million three hundred thousand tons of Japanese shipping — more Japanese tonnage than was destroyed by all other Allied forces. This amounted to twenty-nine per cent of all Japan's warships and five per cent of her merchant fleet. Yet the silent service totalled only forty-five hundred officers and men — scarcely one and one-half per cent of the Navy's manpower. The Allies in the Atlantic war, on the defensive for a good part of the time, spent for defense measures against the U-boats seventeen times what the Axis spent to wage its submarine war — and lost twenty million tons of shipping to the bargain. Unless more efficient anti-submarine weapons such as the Killer sub are developed, we can anticipate even more imposing statistics in a future war. With atomic power in the engine room, homing torpedoes in the tubes, and remote controlled buzz bombs just below the deck, the submarine of tomorrow becomes one of the most lethal, formidable weapons yet devised in man's constant struggle to destroy himself.

south korea—aggressor

(*Continued from page 7*)

In spite of being convinced that America has many of the characteristics we ascribe to Russia, the students expressing opinions were evenly divided on the question of American democracy. There is a large fraction, about one fifth of the total, who are undecided about how closely America lives up to its own billing. This very important group shows up in a question below regarding the advantages of Communism.

It is interesting to note that the students seem to be comparatively certain of their knowledge of the conditions within the United States; the "Don't Know" totals are low on questions concerning the present material condition of our country, but not on those regarding our future political intentions. It is curious that they feel so little doubt about the conditions in a country they have never seen, when the only real contact they have had with us is through the foreign policy of which they are so dubious.

III. Opinions on Communism

1. *Will Communism be a greater or lesser political power fifty years from now?*
   Greater 129; Lesser 38; Don't know 47.
2. *The "advantages" of the economic security offered by the Communist way of life are greater than the "disadvantages" due to the loss of individual liberty.*
   Yes 100; No 101; Don't know 37.

The very important second question is the point about which we must be most concerned. It tests the reaction of the Italian student towards Communism rather than America. The answer again provides a challenge to our powers of persuasion; the students are almost evenly divided, with a considerable portion undecided as to the advantages of the Red system. The numbers are almost exactly identical with those expressing the opinion that America is truly democratic. That is, the sample taken was collectively on the middle of the political fence, with one hundred students on each side and fifty in between. If the democracies could win a large majority of the undecided ones to their side, they would enjoy a considerable advantage. The task is right before us: we must sell ourselves to the portion of Italian youth who hold the balance of power. Of course it is impossible to determine how many of the students are Communist fanatics who can exert an influence far greater than their numbers would indicate, but it is probably small. If the majority of European youth distrusts Russia, the Communists will be limited in their own breeding grounds.

IV. Opinions on Technology

Technical progress will have the following consequences:

1. *An improvement of the standard of living of the entire world.*
   Yes 196; No 42; Don't know 11.
2. *A greater concentration of wealth in the hands of few at the expense of many.*
   Yes 40; No 189; Don't know 10.
3. *A great influence on the working classes.*
   Yes 11; No 202; Don't know 17.
4. *Better standard of living for the worker.*
   Yes 197; No 32; Don't know 15.

(*Continued on page 22*)

—the mouth that'll never be kissed

Until Bell Laboratories scientists design an electric mouth that can pucker, the human model is here to stay. But we have built a machine that can imitate human vocal characteristics – from the slate-pencil squeal of a girls' cheering section to the basso rumble in a men's dining hall.

Sound being a basic raw material of the Bell System, we have pioneered in the science of speech. Measuring the properties of your voice leads to better and cheaper ways to transmit it.

Keeping the world's best telephone system growing for our country is a big and challenging job. There are opportunities for college men with the right qualifications not only with Bell's corps of research scientists, but also in engineering, operations, and administration, with the Bell Telephone Companies and Western Electric, the System's manufacturing and supply unit.

Your campus placement office will be glad to give you more information.

BELL TELEPHONE SYSTEM

foreign student summer project

(*Continued from page 9*)

and other large nuclear research apparatus. He collects data that will take two years to evaluate; this work, of course, can and is being done in Germany.

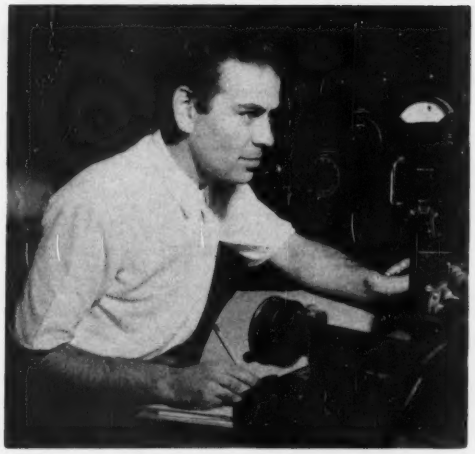
Such is the picture of a typical FSSP participant.

The preceding fairy-tale type narrative is not intended to produce an effect which would perhaps have appealed to Horatio Alger; it has a more serious purpose. That is to show how opportunities constantly arise out of a basically sound idea. It is in this way that progress can be achieved.

Turning to more practical matters, it is well to point out the financial side of such a venture. To enable equal participation by all, expenses of the participants while at MIT are paid in full. On the other hand, foreign countries and their governments reciprocate by providing for oceanic travel expenses. Members of the student committee managing FSSP take much pride in the fact that administrative costs (including a full-time secretary) have always been kept at about ten per cent of the total amount. Raising the necessary funds (last year's budget, that is, money spent directly by the committee, and not including the grant of free tuition from MIT, etc., was $62,000) was a forbidding task at first, with appeals directed through all media of modern publicity toward "give us $1 or $1,000." They did not fail, for FSSP is still "in business," and it might even be termed a "better risk" on the basis of past record. At the present time, the bulk of contributions comes from private foundations, individuals, and corporations; substantial amounts have, in the past, also come from government sources. Special credit is due to Mr. Alfred P. Sloan, Jr., whose interest in the project has increased with the years and who has contributed very generously.

Much emphasis has been laid on raising funds from corporations, as the committee feels that American business as a whole has a very real stake in this undertaking. As it is an educational activity, contributions to FSSP are tax-deductible. Committee members have traveled all along the East Coast, contacting industrial companies of the most diversified nature; informing, arguing, and — in many cases — convincing business executives of the Project's merits. It is a difficult but fascinating task for the students, and an invisible but integral part of that kind of education which does not consist in attending lectures, studying books, or computing figures. On the other hand, contributions from corporations are an especially potent argument that presents to the foreign students the true face of the American free-enterprise system. Most of them are amazed and profoundly impressed to hear that corporations contribute at all.

Now it is no longer possible to remain silent about some of the other, no less important, aspects of this Project. Much of the effort goes toward giving the participants a better understanding of the American economic, political, and social system. Seminars are conducted at



Ettore Dalla Volta, FSSP Participant at Work in Laboratory — July 1950.

frequent intervals. Bull sessions are organized, and some 35 countries are represented on these occasions. The discussion cannot fail to be lively and instructive. Participants are invited to American homes on week ends. They take part in sports, dances, picnics. They visit plants in the Boston area to become better acquainted with American industrial practices and production methods. After the end of the summer program in September, they are invited to go on a nationwide tour of plant visits sponsored by the National Association of Manufacturers directly for FSSP.

A unique innovation in the Project, first tried last summer, is a week-end conference on international

(*Continued on page 22*)

Visiting the General Electric Co., First Stop on the NAM Tour — September 1949.

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how small?

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foreign student summer project

(*Continued from page 20*)

problems. Last year's topic was "Social Progress Through Technology — The Human Conditions of Economic Growth." The minutes of the conference were published in a fifty-page booklet — an impressive array of basic problems and proposed solutions as presented by leading American authorities and criticized or elaborated upon by the FSSP participants of four continents.

In order not to become submerged in details, a final thought. Every effort is being made to maintain the Project at maximum efficiency. First, this means that there is no "vacationing," but rather creative research work. Whenever possible, equipment is set up before the arrival of the participant; also he is given an opportunity to discuss his project with the professor in charge prior to landing here. Other activities than research are so arranged as to provide recreation when it is needed. Second, the Project lays claims to being a good investment: it is well planned, well administered, well accounted for. The cumulative experience of the past years is of great importance here.

It is fitting to conclude with what happens after the summer is over and the participants are *required* to return to their home countries. (This is one of the basic policies, consistently followed in the past.) Hopes are high here, too; there are also solid facts for those who want to judge issues from that standpoint. An alumni association of past participants is being formed. The association has already started to publish a quarterly magazine; it is only natural that articles of interest are not at all unusual: "Unions for College-Trained Engineers and Architects in Sweden" (excerpt: ". . . But some results have been gained. As mentioned above, the government is the 'toughest' employer, very unwilling to pay qualified people well. As more and more engineers get informed, the difficulties of the state to find good men increase. Thus it has been forced to relax its equalization policy for engineers, who rather easily get good jobs in the private industry."); "Newsletter from India" (describing industrial development of the Damodar Valley. Sample: ". . . As cheap power becomes available, the mines will be mechanized and production from the coal mines in the Valley will be stepped up. With power reaching the hills and jungles, the mica mines will be electrified and mechanized.")

It is already very apparent that the past participants, who were selected on a "cream of the crop" philosophy, are steadily advancing up the ladder. The fact that these men are on the way to attaining leadership in the technical and scientific as well as the social fields in the various countries cannot be appraised too highly. It is their influence, their knowledge of America (made possible through FSSP) wherein lies the real promise of better international relations in the future.

(*Inquiries concerning this article are welcome. Correspondence should be directed to Foreign Student Summer Project, Walker Memorial Building, M. I. T., Cambridge 39, Mass. The committee will be glad to provide any additional information.*)

For Sale

One Stuffed Stetson

south korea—aggressor

(*Continued from page 18*)

The students were generally hopeful about the effects of increasing technology. The belief that everyone, not just the rich, would benefit from scientific advancement but that laboring classes would not be affected to a great degree seems to show rather confused thinking. The students do not seem to fear an exploitation of the masses caused by labor-saving devices in factories. Of course these students will probably be the very technicians who benefit most from such advances, and they might reflect their own optimism concerning science into their opinions concerning technology's effects on others. All in all, probably a poll of American students would show roughly similar results.

Conclusions — Editorialized

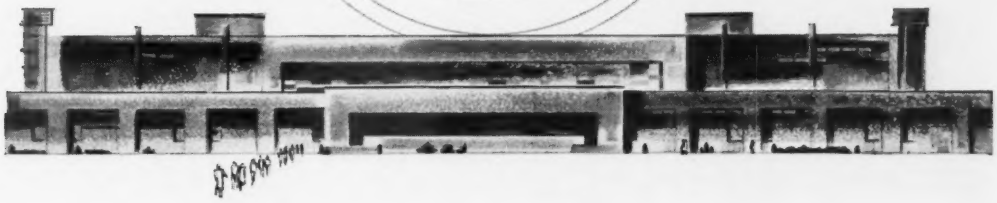
While our sample was unfortunately very small, the poll at least gives a very rough idea of the American position in the ideological cold war. The results, coming from a country supposedly under considerable American influence, come as quite a disappointment to most of us; like humans everywhere, we can't see how other people can believe something we think is completely false.

The misunderstanding shown in the poll merely makes an acknowledged fact again obvious: we have used a poor method of gaining Europe's confidence. The billions of dollars' worth of material goods we have been exporting overseas might have engendered friendly feelings and gratefulness towards us, but we have not bought any real understanding of our true nature, ideals, or motives. We must export our ideas as well as our wheat or dollars. To most of the students polled we seemed to be a materialistic, imperialistic power dominated by a Wall Street clique. If we merely ship them more arms and food, we do nothing to dispel this notion. Every time one of our officials seems to expect a country receiving American aid to adhere to American foreign policy, it only serves to convince skeptical Europeans that we are buying their support to save our own skins. But still we tend to estimate the price of securing a united, anti-Communist Europe in terms of tanks or bread. How many bushels of wheat made up for one speech asking why we continue to send money to countries that didn't jump at the chance to join the Atlantic Pact? Every reference we make to "letting the Europeans fight the war for us" will sound pretty sour to the youth who is going to do that fighting.

On the other hand the Communists, with all of their promises of more food and greater security, have done no better than we have. The proportions seem about equal. If we are smart and careful, we can reduce the Communist threat to a small portion of the youth. If not, we may lose considerable support.

The poll merely makes it obvious that we are not dealing with Americans on the other side of the Atlantic. Most Europeans do not just assume which side is better the way almost all Americans unconsciously do. Yet the European cannot make an unbiased choice either because all of the information he receives from both sides is extremely slanted. These Italian students showed the effects of this conflict by a disbelief of both American and Russian claims to superiority. But both Italy and the United States would benefit from mutual trust and friendship. Can we bring this about? We had better!

NEW research expansion AT DOW



Research is the cornerstone of rapid growth in the chemical industry. The continuance of this growth at Dow is assured by expanded research facilities requiring the talents of many scientific people in widely varying fields of endeavor.

At the home plant in Midland, Michigan, Dow is building another completely new laboratory to augment the current work in organic chemistry. Increased facilities for Dow's progressive work in spectrographic analysis is planned to keep pace with important advances in this field.

In Dow's Freeport, Texas Division, even greater research expansion is taking place. Here a huge research center consisting of eight buildings is under construction. This center, which will include a modern technical library, will have a total floor space of 57,000 square feet.

Dow's booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to The Dow Chemical Company, Technical Employment, Midland, Michigan.

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Top-of-the-list cause of fires, according to study after study, turns out to be just plain human carelessness.

Under the heading "Careless smoking habits" you'll find such oddities as the waitress who cleaned *hot* ash trays with napkins destined for the laundry chute, and the mechanic who tossed a match into a puddle of gasoline. But far, far more frequently it's simply the ordinary guy who unthinkingly tosses away a lighted match.

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Education does a world of good to prevent fires from *starting*. But until human behavior is perfect, your best protection lies in *automatic control* of fire.

The surest control is with Grinnell Automatic Sprinkler Systems, which check fire at its source, wherever and whenever it may strike, with automatic certainty. For more than seventy years fires starting in buildings protected by Grinnell Sprinklers have been extinguished before doing material damage.

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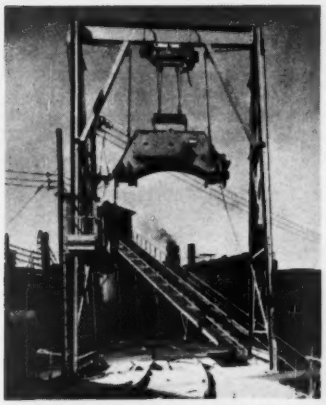
"Find Yourself"

...without losing time!

by FLOYD O. SMELTZ, *Supervisor, Standardization Section*
WEST ALLIS WORKS (*Graduate Training Course 1950*) *Ohio State—EE—1949*

FLOYD O. SMELTZ

SELECTING a specific job in the engineering field after graduation from college is a tough proposition for most of us. It was for me, and that's why I came to Allis-Chalmers. I thought I wanted to be a development engineer but I wasn't sure. Allis-Chalmers Graduate Training Course gave me an opportunity of trying design and development—and other types of work also. By my own choosing I am now engaged in challenging work which I hadn't even considered while in school. The point is, all GTC's have the same chance of "finding themselves."



Allis-Chalmers car shaker empties coal and ore cars in minutes. Saves time . . . prevents injuries by keeping men out of car interiors.

That's the outstanding feature of Allis-Chalmers Graduate Training Course. You have a very broad selection, and you yourself choose the type of training you receive. Of course you get help and guidance from experienced men throughout your training period. You need it, since there are jobs here that you have never dreamed of.

Finds Job Challenging

Take my job for instance. To the engineering student it probably sounds rather dull when compared with Advanced Thermodynamics or Electric Transients in Power Systems. But, in my opinion, the most fascinating science is coordinating engineering and production efforts through standardization of procedures, parts and materials. As Supervisor of the Standardization Section and Chairman of the Standards Committee, I encounter new problems every day—no monotony here.

But that is only part of the story! I am also Secretary of the Chief Engineers' Committee and Secretary of the Development and New Products Committee. What could be more stimulating for a young engineer than to be at the crossroads, where he can watch the engineering planning of an expanding company?

No Limit to Opportunities

I never thought I'd be doing this when I graduated from Ohio State in 1949 and enrolled in Allis-Chalmers Graduate Training Course. As I mentioned, I was particularly interested in design work at that time. In fact, right now there is a patent applied for on an electro-magnetic relay device I designed. Yes, they even let me do development work while still a GTC student.

A student helps plan his own courses and is free to change his plans as new interests, new opportunities present themselves. He can divide his time between shops and offices—switch to design, manufacturing, research, application engineering, sales, or advertising—and can earn advanced degrees in engineering at the same time.

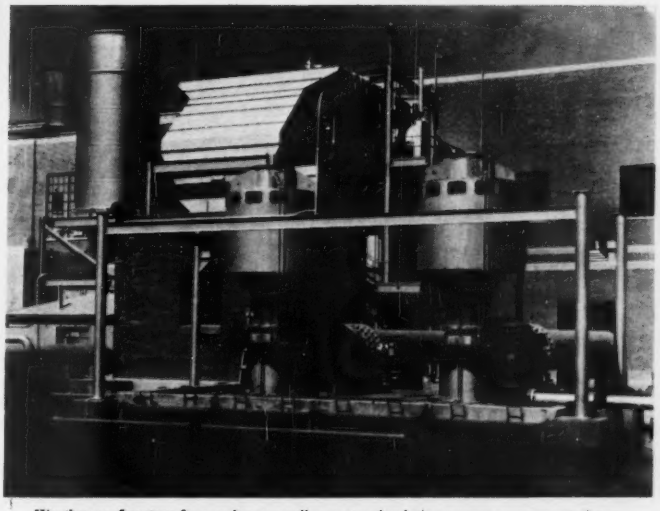
When he graduates from the course he is encouraged to go into the type of work he liked best while on the Graduate Training Course.

One of the reasons Allis-Chalmers offers so many opportunities is that A-C designs and builds machines for every basic industry, such as: steam and hydraulic turbine generators, transformers, pumps, motors, rotary kilns, crushers, grinders, coolers, screens, and other machinery for mining, ore processing, cement, and rock processing. Then there are flour milling, electronic equipment and many others.

There is no other organization that seems to me to offer the graduate engineer such a wide range of activities, or that gives him such a chance to find the type of work for which he is best fitted.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin



Weatherproof motors for condenser cooling water circulating pumps were mounted outdoors to conserve valuable building space for a Texas utility

living backwards

(*Continued from page 10*)

Still later, some of the masters of Science Fiction tried their hands at exploring the more fundamental paradoxes arising from travel through time. As a result, we were given such fundamental classics as: *By His Bootstraps* (Anson Macdonald [Robert Heinlein], October '41). After the plot unfolds, the hero of the story has been multiplied fourfold, so that there are several of his images bumbling about all trying desperately to get all the rest back at the starting point of the nightmare. The only way to keep track of what's going on is to take a few days off to read the story and to plot a graph of all the alter-persons of the main character, and their movements in time and space. Another fundamental brain-twister came from P. Schuyler Miller's *As Never Was* (January '44). It deals with a knife that an archaeologist found in a time-jaunt into the future. Nobody could analyze the knife's structure. It remained an enigma till the scientist's death, and then was placed on his sarcophagus in his honor. But it turns out that in his earlier trip, *this was where he found the knife.* Now the mystery comes from the following facts: During the time the knife was being analyzed after the scientist had brought it back from the future, some metallurgists had succeeded in taking a sliver from the almost infinitely hard substance for analysis. When the knife was laid on the scientist's coffin after he died, it still had the nick. However, when he picked it up off his tomb (at that time not knowing that it was *his* tomb) during his earlier time trip, it did not have the nick. Problem: Precisely when did the nick disappear, and how?

The concept of a time bubble (for want of a more descriptive phrase) was developed in A. E. van Vogt's *Not the First* (April '41), and in Charles Harness's *Time Trap* (August '48) it was displayed in all its fascinating complexity. The best way to describe a time bubble (as exhibited in the above two stories) is to draw a series of diagrams (see page 10).

In (a) we have, symbolically, the time stream. Imagine the stream to be bent as in (b), and this process continued till a loop is generated as in (c). Then imagine the loop to become disjoint at *A*, so that it becomes a closed loop. The main time stream "heals" as in (d). The time bubble is *B*, and all the occupants in that part of space-time are, by definition, doomed to cycle through the same incidents over and over and over again. For example, in *Not the First*, the crew of a space ship is trying to get out of the region of an unstable star before it explodes. They force their atomic engines beyond their limits, and "disrupt" space-time in their vicinity, generating a bubble. They are doomed to try to escape from the bursting star for "all time." In *Time Trap*, an entire civilization is ensnared in a bubble by an almost omniscient galactic being who is fleeing from even greater galactic beings. In its attempt to hide, the being generates a bubble, and carries an unwitting civilization along with it. The unnerving fact about being in a time bubble is that the occupants are incapable of detecting the phenomenon.

If you had a chance to live your life over again, say from the time you were twelve years old, what would you do in the new life, especially if you retained all the knowledge of your future existence? A fascinating answer to this question was given in *Time and Time Again* (H. B. Piper; April '47). An equivalent situation would exist if you were suddenly in possession of a limited, but adequate pipeline to the future, as happened in Lewis Padgett's *Line to Tomorrow* (November '45), wherein a telephone suddenly becomes "hooked" up with the future fifteen years hence. A roughly similar situation arises when, as in Ross Rocklynne's *Time Wants a Skeleton* (June '41) a half a dozen people are confronted with a skeleton, which they know *must* belong to one of the six. . . !

Novel situations can arise in legal circles if the time travel hypothesis is granted. Lewis Padgett explores such possibilities in his *Time Locker* (January '43), and in *Private Eye* (January '49). In the latter story, the law enforcement authorities are in possession of a "scanner" which can look back into a given individual's life for a "distance" of fifty years . . . nothing is barred from view in that interval of time . . .

Of never-ending interest to writers is the practical application of time travel to everyday life. In *Rat Race* (G. O. Smith, August '47) the present was rid of the scourge of rats by a trap that displaced the captured rodents into the past. There was a catch, though . . . The power to heal human ills by sending the patient into the future where the cure has been developed was presented to the characters in *Time Heals* (Paul Anderson, October '49). Again, there was a pessimistic hitch. Historians and other scholars had a field day in *E for Effort* (T. L. Sherred; May '47), until the Army stepped in and applied the time scanner to more "immediate" problems. Archaeology made great strides in Taine's *Before the Dawn* (*Novels of Science;* D. Wollheim, editor, Viking Press, N. Y.).

Moving merely backward and forward in time began to weary some writers who felt that plus and minus infinity in time was a bit of a cramped situation. Accordingly, Murray Leinster, in his *Sidewise in Time* (Shasta Publishing Co.) developed a concept of parallel existences. More was done in this line by H. Beam Piper in his "paratime series," starting with *Police Operation* (July '48). The Earth was hypothesized to have five parallel, coexisting worlds. Each of the five was supposed to have started in the remote past of the Earth's history, when the planet was populated by interstellar visitors. Several crucial events occurred during that time which offered five diverging, possible histories of mankind. In *Police Operation* the adventures take place in this kind of space-time structure.

Of never-ending fascination are the plots which toy with the idea of anachronisms. What effect can a genuine anachronism have upon a series of events? Some specific instances would be found in Isaac Asimov's *The Red Queen's Race* (January '49). A professor in modern times sends back to the Greeks a translation of a modern chemistry text, with a surprising result. An hilarious situation arises when a fully armed infantryman of the Italian Occupation forces during the past war is accidentally precipitated into the time of Nero, and is doomed to combat in the arena. He is armed with a bazooka, hand grenades, pistol, and carbine. The elephants and assorted beasts don't have a chance . . . and another visitor from the future complicates things. This action takes place in L. Ron Hubbard's *The Obsolete Weapon* (May '48). More unsettling and thought-provoking situations arise in Padgett's *Mimsy Were the Borogroves* (February '43). What would modern-day children do with the toys of the remote future? Another example would be found in *Child's Play* (William Tenn; March '47).

Why haven't we ever had evidences of time travelers? "Surely that would give us plenty of proof that no such beings ever existed, or will exist," would be

(*Continued on page 30*)

What Are They?

- ☐ *Thrust bearings*
- ☐ *Clutch disks*
- ☐ *Grinding wheels*
- ☐ *Ceramic insulators*

The correct answer is grinding wheels, shown as they emerge from the electric kiln.

Not ordinary grinding wheels, however. They are Norton *New-Process* Wheels — made by modern, streamlined, precision methods developed by Norton engineers.

A Big Step Forward

This new process involves advanced equipment, new manufacturing techniques, and close quality control during every step of grinding wheel production. As a result, Norton *New-Process* Wheels are produced to a degree of structural uniformity never before possible.

This increased uniformity means extra assurance of consistent grinding action throughout each wheel and from wheel to wheel. Which, in turn, means more evenly wearing, longer lasting wheels — together with more cutting action per wheel and per dollar.

In addition, the built-in balance of Norton *New-Process* Wheels cuts down vibration and enables them to hug the work more closely, assuring smoother, better grinding performance.

A wide range of wheels employing both ALUNDUM* (aluminum oxide) and CRYSTOLON* (silicon carbide) abrasives are made by the new process.

Looking Ahead With Norton

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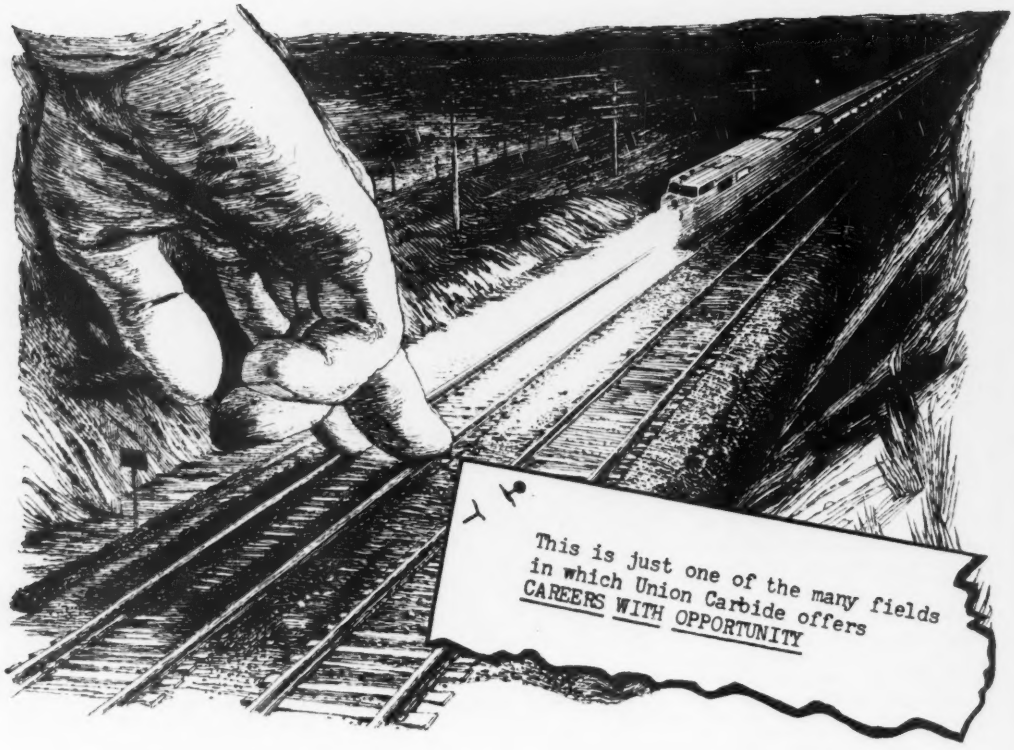

Clearing the track of clickety-clack

You can ride in comfort on longer-lasting rails because the song of the track is being stilled

Like the paddleboat whistle on the river, the clickety-clack of wheels on rails is on its way to becoming a memory.

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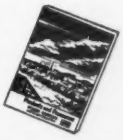

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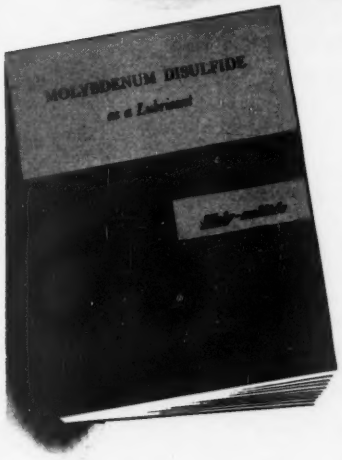

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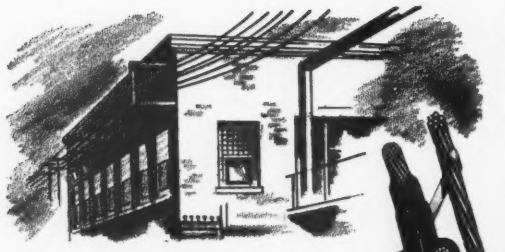

How to lick dust, moisture and acid fog

prevalent in the atmosphere surrounding the Rumford, Me., mill of the Oxford Paper Company posed a problem in power circuit maintenance. The combination of these elements caused wooden structures and even over-voltage insulators to become conducting, resulting in phase-to-phase flashovers and burndowns when ordinary overhead wires were used.

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Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE insulated wires and cables

8786

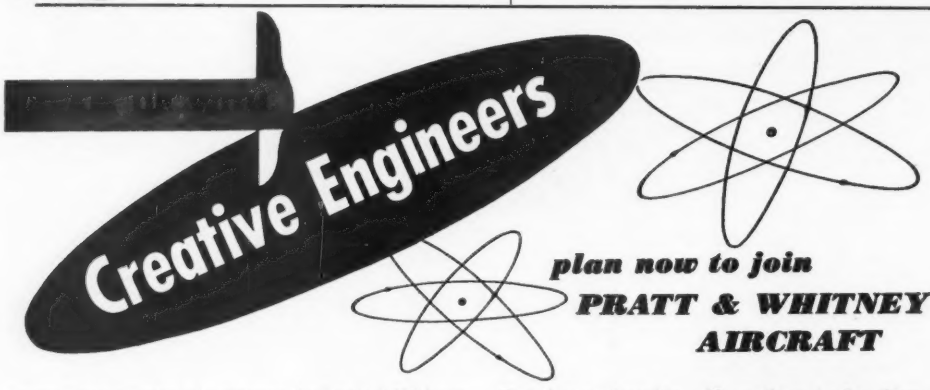
living backwards

(*Continued from page 26*)

the comments of some. The concept of the intrinsically elusive time traveller is developed in *Vintage Season* (Lawrence O'Donnell; September '46). They might be around us right now for all we know, and one possible reason for our not detecting them or recognizing them is given in the speculative account, *The Helping Hand* (Burt Macfadyen; January '48). Or then again, there really might not be any time travellers in the present, and for a non-trivial and most unusual reason, Anthony Boucher's *The Barrier* (September '42) beats them all. Then again, there are some very unusual disappearances in real life that would lend very nicely to some sort of time travelling hypothesis. *He Walked Around the Horses* was H. Beam Piper's (April '48) attempt to rationalize a documented disappearance of a very suspicious nature.

To round out this small list of time travel themes, we recall Anthony Boucher's *The Chronokinesis of Jonathan Hull* (June '46). Here a detailed and logical account of living backwards in time is presented. Another example of a reversed world-line was detailed in M. C. Pease's *Reversion* (December '49). In the latter story, a worker in an atomic project is brought in after an accidental explosion. His muscular coordination, and his environmental orientation seem to have been completely destroyed. He is a hopeless puzzle until a doctor thinks of reversing a tape recording of his seemingly unintelligible babbling. The unfortunate plight of the individual is then discovered. There are infinitely more unpleasant things arising from backwards travel in time than from the normal course; and

(*Continued on page 40*)



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quantum mechanics

(*Continued from page 11*)

cation, one cannot determine exactly the occurrence of events on the basis of past experience.

Of further interest here is the tenet of quantum mechanics which maintains that predictions of great certainty can be made when one is dealing with a large number of electrons. As an example, the diffraction produced by a group of electrons can be determined exactly. It is important to note the difference between this kind of prediction and the type made in statistical analysis. In statistical analysis, nothing can be said as to the actions of the individual elements which make up the group. However, in quantum mechanics one can compute the probable action of the individual particles.

We can now leave the field of atomic physics and enter the domain of human behavior. Before formulating the beginnings of a philosophy, it can easily be demonstrated that the determination of one's own will is independent of the law of causality. The existence of causation implies that, were we to know the sequence of all events and their relation to one another, we could predict the future. In other words, man is not free in his will, but is buffeted about in a world tied down by cause and effect. Then one could, in order to increase self-knowledge, determine from the law of causality the activities and motions of one's will. Such an attempt is bound to fail, because every application of the law of causality to the will would produce knowledge of the will which would itself act as a motive and thereby change the result. It is thoroughly mistaken to say that it is impossible to predetermine our activities because we are incapable of knowing about all phenomena. That would correspond in physics to the assertion that the impossibility of exactly determining at the same time the position and speed of an electron is due to the incompleteness of the observations. No, the impossibility is due to the condition that no method which transforms an object is suitable for examining it.

We can now apply the above ideas more generally. However, in order to formulate a philosophy free of assumptions not warranted by past experience, we must use the approach known as logical positivism, or operationalism. In part, operationalism states that only measurable quantities are given any meaning in our system. This methodology excludes all discussion of the influences on human affairs by devils, angels, ghosts, etc. Then, in order to fit free-will into our framework we must first define it. According to A. L. Friedman, we can define the amount of free-will a body contains by how capable we are of predicting its actions. This statement does not imply, for instance, that dice have free-will; for, if our measuring instruments were fine enough and proper enough, we could describe all their motions and predict "boxcars" before their occurrence. Yet, according to our definition, we can never predict the actions of bodies containing free-will, but can, at least theoretically, derive the future activities of bodies not containing free-will.

How do these ideas apply to human beings? Many psychologists maintain that, with enough information, we could predict the actions of human beings. Thus, one is inclined to believe that man has no free-will. A simple analysis shows the error of this conclusion. The manner by which one gets information about human beings in psychology is through standardized tests or through experiments of various kinds. In order to measure the free-will of a person, we would set up a standard set of circumstances and attempt to completely describe the person's consequent responses. Again, we are bound to failure. For, in order to take measurements, we need to move the man into the area of the circumstances; thus, we need his cooperation. Getting this cooperation produces motivation which directly affects his will. A striking example is the results of an experiment conducted by Western Electric Co. The purpose of the project was to determine those conditions in the factory which increased the workers' output. Additional information as to various attitude formations was also required. The method was to place factory workers, who had volunteered for the experiment, in a separate room in the plant. The conditions under which they worked varied from month to month — different types and intensities of illumination were used, the temperature of the room was varied, the quality of their lunches changed, etc. It was found that every time a change was made, no matter what the change, production went up. The conclusion was obvious. The volunteers, knowing they were part of a project, responded to every change as they thought they ought to respond.

Of course, the experiment could have been done without the workers being aware of it. Different conditions could have been instituted in different parts of the factory. We could then have determined which area showed the highest production figures, and extended the changes to the entire factory. But, all we could have said then about the behavior was that this or that factor changed the workers' production. We could say no more, for to determine other aspects of behavior going on at the same time, we would have to alter the conditions of the experiment, thus changing the direction of the will. We can, therefore, state that the will, though its direction can be determined to some extent, can never be completely described.

It is conceivable, nevertheless, that a completely different approach than that used by psychologists might enable us to determine human behavior. The only other attack is the mechanistic outlook. The human being, according to the approach, is nothing more than a high class servomechanism, a series of electrochemical circuits and complicated feedbacks. One feels, then, that because it is possible to describe circuit behavior completely, it is possible to describe the response to various stimuli of "human circuits." However, such an analysis on human beings involves much more than circuit and chemical analysis. As opposed to such treatments, the change in neural "wire" construction with time, the formation of additional circuits with growth, the disappearance and appearance of feedback loops, means a deep and detailed investigation of individual molecules, atoms, and electrons. According to quantum mechanics, a complete description of these particles can never be given. Thus, this approach must fail in determining human behavior completely.

We conclude, then, that man has partial free-will. Moreover, the more completely we determine one aspect of behavior, the greater is the indeterminism attached to other behavior. This result falls between the opinion of various churches on one side and the stand of the scientific and philosophic determinist, on the other. Of extreme importance in judging our results is the fact that they correspond to our everyday world of observations, for we all are aware that forces act upon us which enable us to predict what a person may do.

It is also known that predictions of great certainty can be made concerning the actions of groups. For

(*Continued on page 36*)

What's Happening at CRUCIBLE

about special shape type steel

5. The flash trimmed off after the swadging operation.

6. The finished type ready for hardening, plating and soldering to the type bar.

The production of Crucible steel for this job is the result of engineering and practical know-how combined with a special method of manufacture to assure a homogeneous microstructure for maximum forming properties, excellent surface characteristics for good die life, and close accuracy control for all dimensions of the shape.

The production of type steel requires the use of small precision rolling mills equipped with shaped rolls and operated by skilled workmen. During preliminary and final inspection, shadowgraph equipment is constantly used to check for size accuracy.

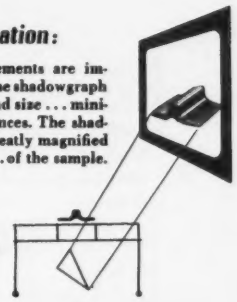
As a result of its outstanding quality, Crucible's special shape type steel is constantly in demand and used by leading typewriter manufacturers.

Crucible special purpose steel for type character application

The development of cold rolled special shape type steel is one of Crucible's important contributions to the business machine industry. A major part of the type characters used for the manufacture of typewriters are made from this special shape.

Shadowgraph Operation:

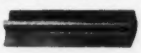
Since micrometer measurements are impractical due to the shape, the shadowgraph is used to measure shape and size . . . minimum and maximum tolerances. The shadowgraph is a projection, greatly magnified . . . on a calibrated screen . . . of the sample.



Schematic of shadowgraph

Here's the step-by-step process:

1. Cold rolled special shape produced by Crucible.



2. The type slug cut from the special shape material.

3. The wings of the type slug are bent down and taper formed toward the edges.

4. The type characters are cold swadged on the solid edge of the bent type slug.

If you have a requirement for special steels—check with Crucible. Feel free to draw on the experience of our metallurgists and engineers. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

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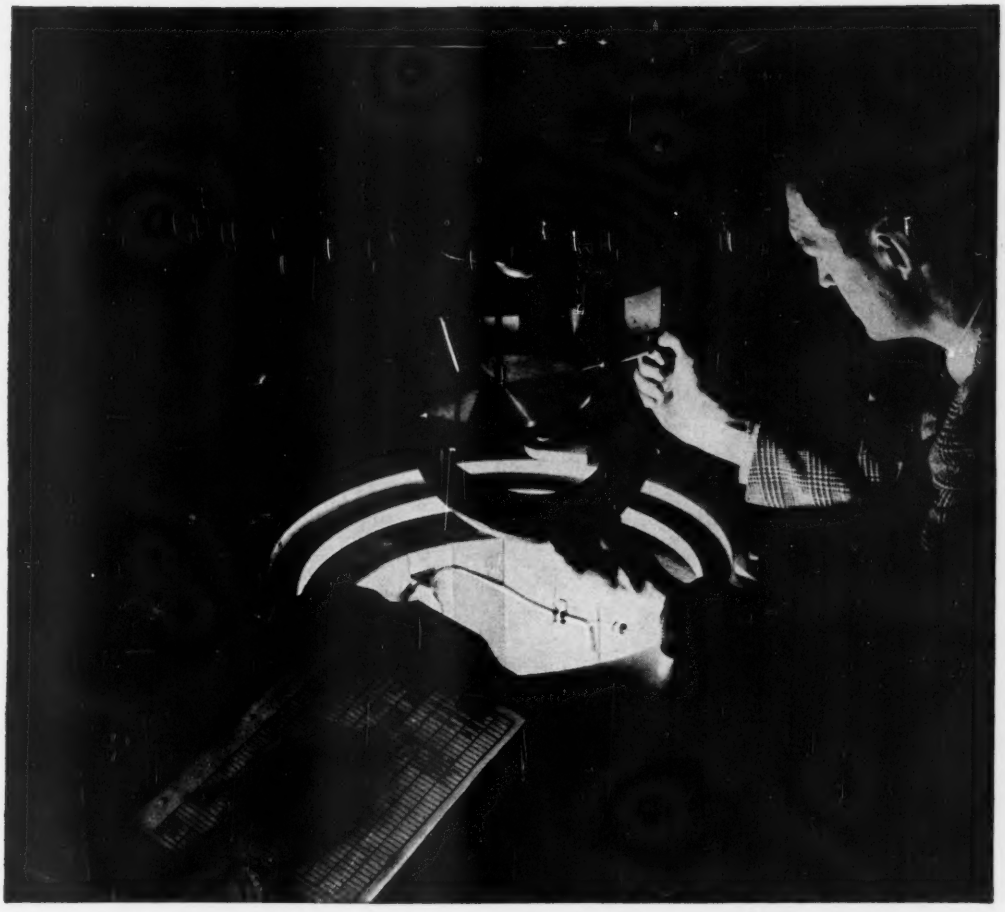

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dogma. Instead philosophers must examine the implications of modern science to discover whether the deepening of knowledge produced by the brilliant successes of scientific research can be extended from nature to the domain of human institutions.

Schultz

is

Dead

quantum mechanics

(*Continued from page 32*)

instance, I can say with assurance that 3,500,000 people will ride in New York's subways tomorrow. This type of prediction is different from that of determining the results of an election, for in the latter case we do not necessarily have any experience to guide us. Only those types of group behavior repeated in time and space can be predicted.

Applying these ideas to past philosophies, we note that those systems which have their roots in determining the actions of the individual are not valid. For instance, Plato developed his Republic on the premise that the individual's behavior was completely determinable, that society could regulate it once the principles upon which the will operated were found. That such principles cannot be found has been shown above. On the other hand, the knowledge that the activities of certain types of large groups can be predicted indicates the basis of social-philosophy. To control the destiny of society, we must look for a political structure which tends to control the actions of groups, rather than individuals.

The above arguments are only meant to be of heuristic nature, and not to be logically complete. It is important to be aware of the fact that science has brought our world of everyday concepts into question, and that philosophers using such concepts must re-evaluate their systems. They must not, as some modern philosophers do, ignore science, for philosophy without science is fruitless speculation, as science without philosophy is empty research leading to

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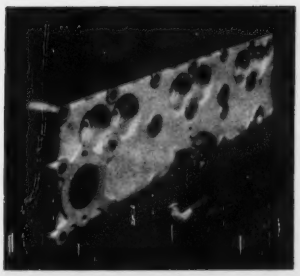

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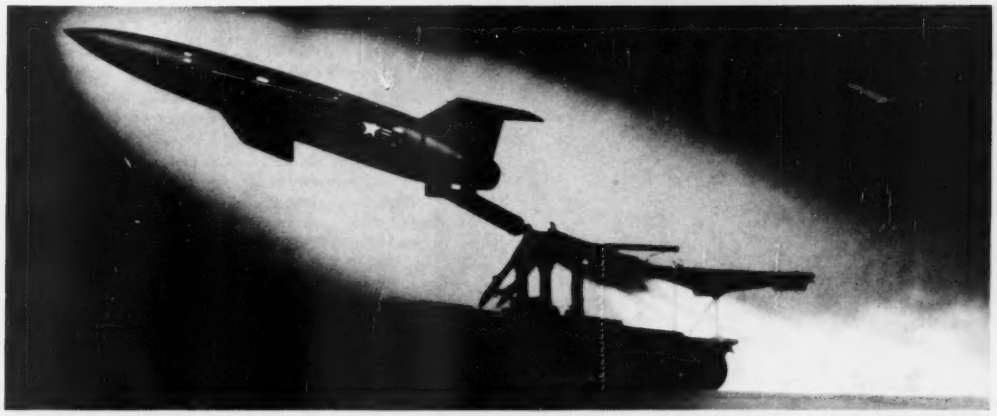

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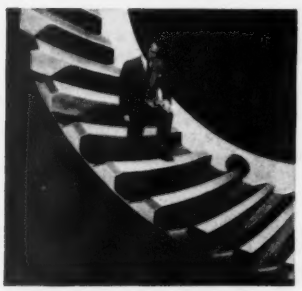

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Your own concern with "problems without precedent" is the reason why we bring you this message here. Whether you are a potential customer of CARBORUNDUM or a potential member of our great engineering staff, we welcome your interest—and your inquiries.

Look to* CARBORUNDUM** TRADE MARK ***for the real news about "man-made minerals"

THE CARBORUNDUM COMPANY, NIAGARA FALLS, N. Y.

Products by CARBORUNDUM include Grinding and Cutting-Off Wheels, Discs and Sticks... Coated Abrasive Sheets and Belts... Waterproof Abrasive Paper ... Abrasive Grain and Powders and other abrasive products... Electric Heating Elements and Ceramic Resistors... Grain and Briquettes for deoxidizing steel and iron... Super Refractory Bricks, Special Shapes and Cements... Porous Filter Media and Diffusers—and are marketed under the following trademarks:

CARBORUNDUM • ALOXITE • MX • RED-I-CUT • GLOBAR • FERROCARBO • CARBOFRAX • ALFRAX • MONOFRAX • MULLFRAX

APPOINTMENT WITH TIME

When you travel by train (or, for that matter, by plane or any public carrier) you expect to arrive on time. Unconcerned, you click-click across switches in the yard district . . . swish past the clang of grade crossings . . . roar by freights only a few inches away . . . Your confidence lies in experienced railroaders and properly maintained roadbeds and signal equipment.

Over every mile of track, your safe and speedy progress is guarded. Guarded by semaphores, position and color light signals, dwarf signals, automatic train controls, interlocking control machines in far-away towers, and other elements in an all-inclusive safety pattern.

An *unseen essential* in this safety pattern, reliable and hard-working, is *Synthane.* Synthane is a strong, light-weight, laminated plastic. It's an excellent electrical insulator, moisture and chemical-resistant, hard, tough and dense. It is also easy to machine. Synthane is a material for small parts or large on any job where a combination of properties is needed and good performance is a "must".

Maybe you can use Synthane profitably. To find out, send for the complete Synthane catalog. We will be glad to help you with design, sheets, rods, tubes or fabricated parts. Synthane Corporation, 10 River Road, Oaks, Pennsylvania.

Terminal Board (left) for continuous train control and relay pusher (right). Both pieces are made from Synthane laminated plastics for General Railway Signal Co., Rochester, N. Y.

Synthane—one of industry's unseen essentials

SYNTHANE

LAMINATED PLASTICS

THE DU PONT DIGEST

Engineering Unlimited

Training in many different engineering branches opens the door to opportunity at Du Pont

In recent issues of the *Digest*, we have discussed opportunities for mechanical and chemical engineers at Du Pont. However, this is only part of the picture. The special skills of more than a dozen different branches of engineering are needed on our scientific teams. For example:

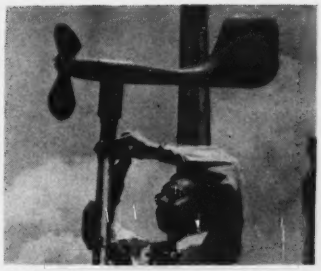
Architectural, civil and structural engineers are attached to the central Engineering Department which handles most of the Company's construction projects. In this work they make site investigations, lay out new plants, design buildings, determine construction methods and specify materials and equipment. They also assemble necessary labor forces at field locations and supervise the building and assembly of complex manufacturing facilities.

Electrical engineers aid in designing process equipment and facilities for power generation and distribution, air conditioning and refrigeration. Instrumentation is another important phase of their work. Continuous automatic analyzers for cyanides, ultra-violet gas analyzers, multivariable recorders, and new photo-multiplier circuits are just a few of their developments.

Industrial engineers help develop methods and standards for new or improved manufacturing processes. This work often serves as training for production supervisors.

Metallurgical engineers play an essential part in the central Engineering Department's program of research. Their studies are aimed at improving equipment and construction materials, as well as methods of measurement and control.

Safety engineers strive constantly to improve the broad safety program initiated by the Company's founder 150 years ago. Du Pont is understandably proud of its safety record, which in 1950 was eight times better than the chemical industry's as a whole, and fourteen times better than the average for all industry.



Carl Gosline, *B.S., Iowa '41, conducts meteorological engineering studies to help solve plant chimney problems involving smoke and acids.*

This by no means completes the list. Every U. S. industry utilizes Du Pont products. Hence there is also a need for specialists in mining, petroleum, textiles and many other branches of engineering.

Along with chemists, physicists and other technical personnel, almost every kind of engineer finds opportunity at Du Pont. Your engineering degree is only a door opener. Any man with ideas, imagination and the ability to handle people will find plenty of room for advancement in this company that has never stopped growing.

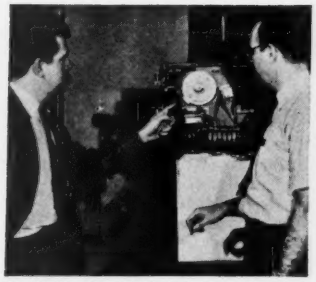
FOR HELP in choosing your career, send for free copy of "The Du Pont Company and the College Graduate." Describes futures for men and women with many types of training. Address: 2521 Nemours Bldg., Wilmington, Delaware.

DU PONT

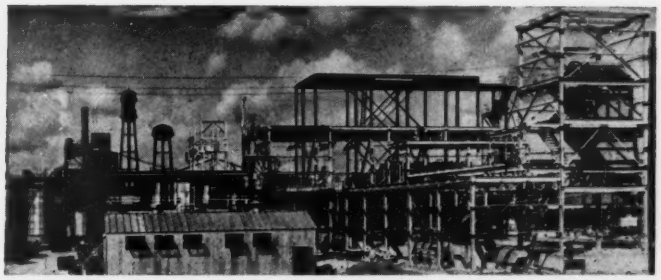
150th Anniversary

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

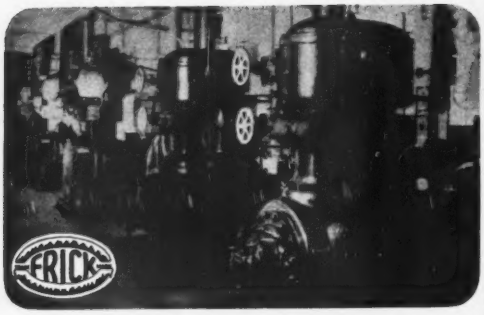
Entertaining, Informative — Listen to "Cavalcade of America," Tuesday Nights, NBC Coast to Coast



Fred R. Struder, *B.Metal.E., Rensselaer P. I. '50, examines a pressure strain recorder with Allen R. Furbeck, E.E., Princeton '39.*



This Du Pont plant, *near Orange, Texas, manufactures nylon intermediates, plastics and heavy chemicals. Engineers attached to The Du Pont Company's central Engineering Department designed the plant and supervised the installation of the manufacturing equipment.*



Snow Crop Marketers

Install Frick Refrigeration

Snow Crop Marketers, a Division of Clinton Foods, Inc., and one of the largest packers of quick-frozen foods in the country, has in operation at Lewiston, Idaho, a battery of five large Frick compressors which produce temperatures as low as minus 40 degrees F. Installation by Lewis Refrigeration and Supply Co., Frick Sales-Representatives at Seattle.

Super-dependability and economy have made Frick refrigerating machines the favorite with quick-freezers, as well as in air conditioning, ice making, and other cooling systems.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years offers a career in a growing industry.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

WAYNESBORO, PENNA. U.S.A.

solar energy

(*Continued from page 13*)

Thus far the greatest research efforts in the utilization of solar energy were in the field of *photochemistry*, notably in photosynthesis. Agricultural research is largely the study of applied *photosynthesis*, with the purpose of increasing crop yields. The forests of the temperate zone convert solar energy into combustible wood at an efficiency not greater than 0.1 per cent. A high corn yield of 100 bushels per acre and the additional fuel value of all by-products of growth, result in an efficiency of 1.6 per cent during the growing season. The primary role of photosynthesis is to produce food. A "fuel-growing" process has been suggested, based on growing a high yield crop, drying and bricketting it and finally burning it for heating purposes. This process, involving transportation costs and labor, probably cannot produce, over a year, a yield greater than 0.4 per cent, which compares unfavorably with the 35 to 40 per cent efficiency obtainable with direct solar house heating.

There is increasing interest in the sun, as an untapped and potentially unlimited natural resource, for heat and for power. Conservative engineers treat this subject with near derision, pointing to the fuel reserves in oil, natural gas, and coal. On the basis of use at the present rate and of use at a progressively greater rate, the estimated fuel reserves of the United States should last for 100 to 1,000 years.

A goal definitely more remote than a life-span is of secondary interest to most people, in particular to many engineers, who prefer to engage in the pursuit of tangible results, achievable within a short time. However, technological changes that may occur during a century may be vividly imagined by comparing the technology of 1851 with that of today. The past fifty years alone saw the automobile and the airplane emerging from the "impossible" category. The horse and buggy appeared as the best solution of the problem of transportation and agriculture fifty years ago. The rapid development of the automobile did more than relegate the horse to the race track; it created entirely new problems and techniques, such as the assembly line, highway construction and gasoline stations, Suburbia, Motels, and drive-in movies.

The direct utilization of solar energy at the present time may be compared to the automobile in its infancy. Like those who preferred the horse, there are those who insist that with domestic fuel reserves assured for another 100, possibly 1,000 years, there is no need to indulge in a search for substitutes. Even if the estimated domestic resources of petroleum and natural gas could last for only ten or twenty years, there are the foreign sources, or other already well-known processes, such as gasification of coal — so they say.

Finally, we have to think not only of the United States, but of the vast, densely populated areas of the world which have no adequate resources of coal or oil.

With the exception of the polar regions solar energy is available everywhere; it does not need transportation facilities and cannot be cut off by sudden emergencies created by man. Solar energy cannot produce soot, fire hazards, and mining accidents. It is the cleanest and healthiest fuel.

Solar energy utilization requires ingenuity in overcoming the scientific, technical, and economic problems. It calls on almost all branches of physics and chemistry and requires the teamwork of specialists in many fields.

The total research and development expenditures made thus far in solar energy utilization are infinitesimal when compared with the expenditures made in the development of other natural resources. Sunlight will be used as a source of energy sooner or later anyway. Why wait?

living backwards

(*Continued from page 30*)

the advantage of having one's memory work both ways, as the Red Queen put it, is a solitary and decidedly unwanted advantage.

And finally we have the harbingers of world doom as only time travel can portray the end of the world. Edward Grendon's *The Figure* (July '47) packs a big wallop for its two and a half pages of story. In it, the groping time machine brings back from the future a statuette of a beetle . . . the dominant species on the Earth at the time. In D. W. Meredith's story, the time machine brings back indisputable evidence that the world will be utterly annihilated *Next Friday Morning* (February '49). And last, but not at all least, is H. G. Wells' cheerless and melancholy painting of the ultimate moment . . . the heat death of the sun in his *The Time Machine.*

There are more stories than we have time to catalog here. This has been a roof-top skimming over the field of SF's stories that have time travel themes. The choice of representative samples has been deliberately kept to the recent past, so that interested readers may more easily procure the copies of the issues involved. Even some recent issues are very difficult to obtain. Now, if we had a Time Machine . . .

You are giving away your standard of living

FANATICS in Germany, India, even some in America, say we should scatter our billions over the world in order to use up our surplus; otherwise (they say) it will dam up on us and cause a depression.

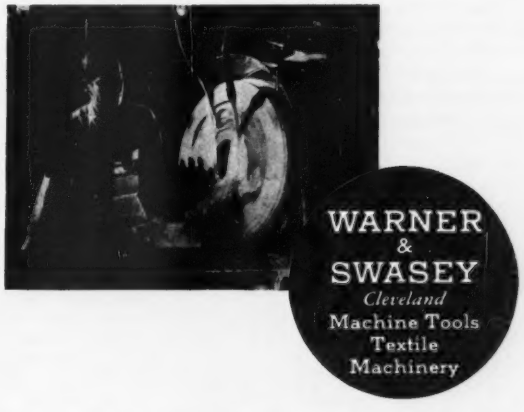
It is entirely possible that we should give away those billions for humanitarian reasons—that is another matter. But don't let's let greedy foreigners and stupid Americans say we're doing it for our own selfish interests. And don't let anyone of us think we are doing it by "soaking the rich". We are giving away (and, remember, perhaps we should, so long as we do it with eyes open) our standard of living.

You and I work, not for dollars but for what those dollars will buy. The more *things* there are in America, the more your day's work and mine will buy. The more steel there is in America, the more automobiles you can get at a low price. The more cloth, the more suits you can own. The more food there is, the better you and your family will eat.

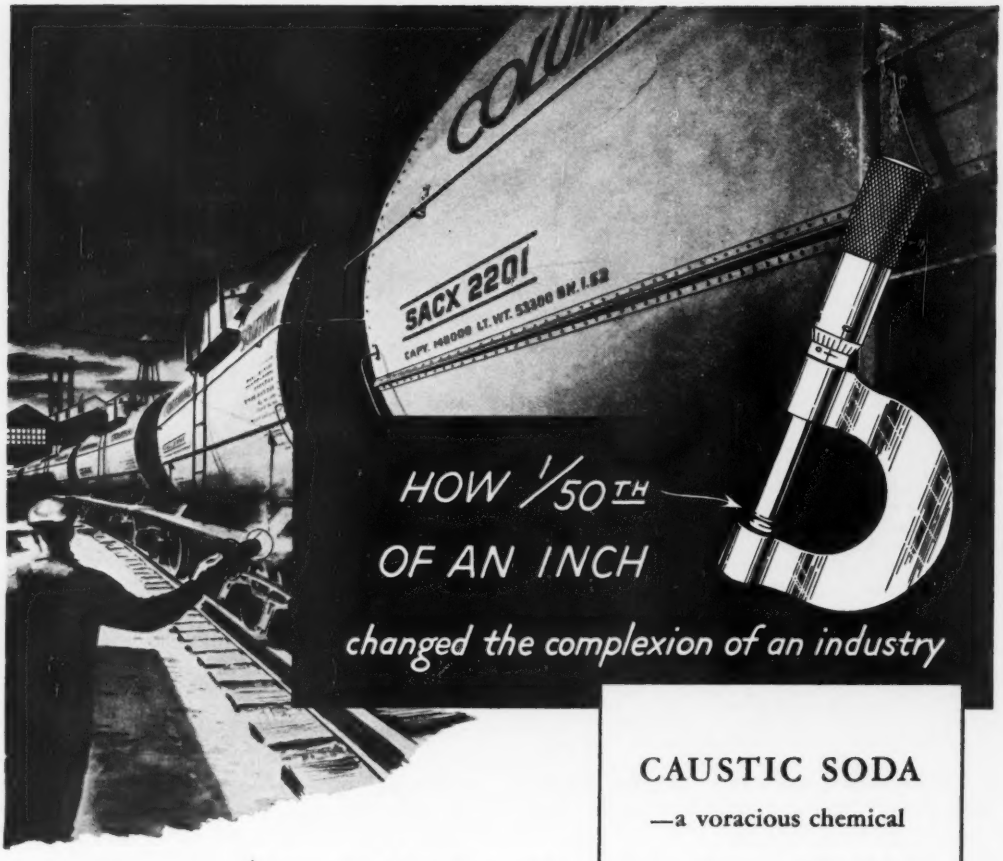
There can only be so much of those things. When you ship them away; you do without. You seldom ship *money* abroad; money is only a token of exchange for the *things* that are going out of this country, out of your reach.

Perhaps that's good, perhaps that's wise. But we should realize what we're doing. Whatever we give away abroad comes out of what we have at home. Unless, of course, each of us produces that much more at his machine or plow or desk *every day.*

If every one of us *produces* more efficiently we can have the satisfaction of knowing we are doing something for the world without destroying America . . . the one strong hope of the world. If we "share the wealth" with the world, we will soon be sharing nothing but poverty. If we share our *increased production* and demand increased production in return, there will then be wealth *and* strength to share.



YOU CAN MACHINE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY TURRET LATHES, AUTOMATICS AND TAPPING MACHINES



A lining for tank cars which is only 1/50th of an inch thick—scarcely more than a film—first made practicable the shipment of liquid caustic soda in high concentrations without metallic contamination. As numerous processes necessitate the use of caustic in its purest form, this Columbia-Southern development has enabled many companies to effect economies in their use of this essential raw material.

In spite of its thinness, this patented lining effectively seals the caustic from the steel of the tank car, and its purity—even at highest concentrations—is safeguarded throughout transit.

This is one of a number of notable contributions to industry which have made Columbia-Southern one of the nation's great producers of alkalies and related chemicals.

CAUSTIC SODA

—a voracious chemical

The usefulness of caustic soda to industry is based upon this very power to attack and break down the chemical structure of many materials. In the manufacture of rayon, for example, caustic soda digests and purifies the cellulose . . . in the making of soap, it decomposes fats. This chemical activity of caustic soda makes it a vital raw material in a wide variety of industrial applications, and especially in the manufacture of other chemicals.

COLUMBIA-SOUTHERN CHEMICAL CORPORATION

SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

SODA ASH • CAUSTIC SODA • LIQUID CHLORINE • SODIUM BICARBONATE • CALCIUM CHLORIDE • MODIFIED SODAS CAUSTIC POTASH • RUBBER PIGMENTS (Hi-Sil, Silene EF, Calcene TM) • CHLORINATED BENZENES • MURIATIC ACID PERCHLORETHYLENE

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AiResearch offers the young engineer of ability unlimited opportunity... in an industry *with a lifetime of expansion ahead*

At AiResearch you work in daily contact with engineers outstanding in aeronautical research. You join a team that has made the dreams of yesterday the facts of today ... that is working constantly on translating today's theories into tomorrow's realities.

Accessories developed and manufactured by the AiResearch Manufacturing Company are vital to all modern high-speed, high-altitude flight.

AiResearch policy is to provide its engineers with fine working conditions, top salaries, and every chance for promotion and self-improvement. There's no ceiling on what you can learn ... *or earn!*

Aircraft training is not necessary. Intelligence and ambition are. There are immediate openings in Los Angeles and Phoenix, Arizona. Apply to: James Crawford, Administration Engineer, Los Angeles.

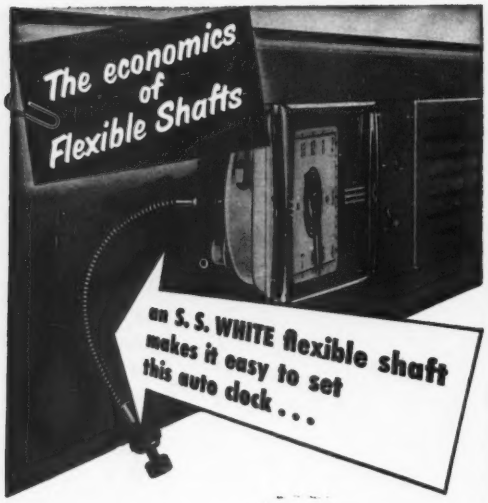
AiResearch Manufacturing Company

A DIVISION OF THE GARRETT CORPORATION

LOS ANGELES 45, CALIFORNIA • PHOENIX, ARIZONA

DESIGNER AND MANUFACTURER OF AIRCRAFT EQUIPMENT IN THESE MAJOR CATEGORIES

Air Turbine Refrigeration · Heat Transfer Equipment · Electric Actuators · Gas Turbines · Cabin Superchargers · Pneumatic Power Units · Electronic Controls · Cabin Pressure Controls · Temperature Controls



When this automobile clock was designed, its manufacturer had in mind the probability of varied instrument panel locations with the resultant need of an adaptable coupling to the control knob. He chose an S.S.White flexible shaft to do the job. As the illustration shows, this simple hook-up permits both the clock and the control knob to be located in its most advantageous position.

* * * *

Many of the problems you'll face in industry will involve the application of power drives and remote control with the emphasis on low cost. That's why it will pay you to become familiar with S.S.White flexible shafts, because these "Metal Muscles"® represent the low-cost way to transmit power and remote control.

SEND FOR THIS FREE FLEXIBLE SHAFT BOOKLET . . .

Bulletin 5008 contains basic flexible shaft data and facts and shows how to select and apply flexible shafts. Write for a copy.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO. Dept. C, 10 East 40th St. NEW YORK 16, N. Y.

calculus by machine

(*Continued from page 15*)

shown that the differential equation of deformation of such a tightly stretched string is in the form:

$$T\frac{d^2y}{dx^2} + \rho\omega^2 y = 0 \qquad (11)$$

where T is the tension in the string, ρ is the mass per unit length, x is the distance from the end of the string along the axis of rotation, and y is the transverse displacement. Typical end conditions are the homogenous conditions that both ends are fixed on the axis. Transforming the equation, the total problem may be stated:

$$\frac{d^2y}{dx^2} = -\frac{\rho\omega^2}{T}\int_0^x\int_0^x \frac{d^2y}{dx^2}\,dx\,dx \qquad (12)$$
$$y(0) = 0 \qquad y(L) = 0 \qquad (\rho, L, T, \text{given})$$

where L is the length of the string. We wish to determine for what values of ω is there a non-zero solution to this (Strum-Liouville) problem. This may be done by adjusting the initial value of y to zero and setting the initial slope at a non-zero value. The end condition is then imposed which consists of adjusting the coefficient $-\rho\frac{\omega^2}{T}$ such that the displacement of the string from the axis is zero at $x = L$. Knowing the values of T and ρ, ω may be calculated by noting the coefficient of the integral term which satisfies this equation.

Many equations of interest arise which contain coefficients that have a finite number of singular points. Bessel's equation of zeroth order presents such difficulties.

$$\frac{d^2y}{dx^2} + \frac{a_1}{x}\frac{dy}{dx} + ky = 0 \qquad (13)$$

The coefficient of $\frac{dy}{dx}$ becomes infinite at $x = 0$. This condition cannot be electronically duplicated, but may be circumvented by starting at a point $x = \delta$, some small value. In many other cases, however, it is not possible to solve the problem directly in the form which it appears. In such instances, the equation is usually transformed such that none of the coefficients behave poorly in the region of interest. One of the most important problems of the utilization of computing facilities is that of determining the form of the equation which yields the most accurate results.

There exist many methods of reading information from the computer. A servomechanism plotter can give a graphical representation of the output, or a "peeping" voltmeter will sample the solution at a point adjustable over the entire computing cycle. Since solutions are of a repetitive form, the voltmeter will give a steady reading of the value of the solution at a particular point on the cycle. A digital interpreter can provide results which are typed in a tabular form or punched on paper tape for further processing. The output mechanism employed depends largely upon the degree of accuracy desired.

Space has limited this discussion to solutions of simple vibrational problems by high speed electronic computing devices. Special techniques and equipment have greatly increased the scope of problems which may be solved by these methods. Because of the increasing complexity of problems of current interest, researchers will undoubtedly rely heavily upon the analog computer.

Hitting modern military targets poses ever-new engineering problems

Increasing emphasis in speed and mobility in modern warfare intensifies the problem of destroying the target—takes it out of the reach of manual ability and into the realm of electronics. Electrical and mechanical engineering—of the highest skill and ingenuity—are required.

Since 1918, Arma Corporation has worked closely with our Armed Forces and American Industry in pioneering and developing equipment to solve such problems. Today, Arma is in the forefront in supplying these precision instruments for our nation's defense, through techniques which tomorrow can be widely applied.

This booklet—"Engineering at Arma"—describes in detail the challenges of an engineering career at Arma. It can open new horizons to you. Write today for your copy to Engineering Division, Arma Corporation, 254 36th Street, Brooklyn 32, N. Y.

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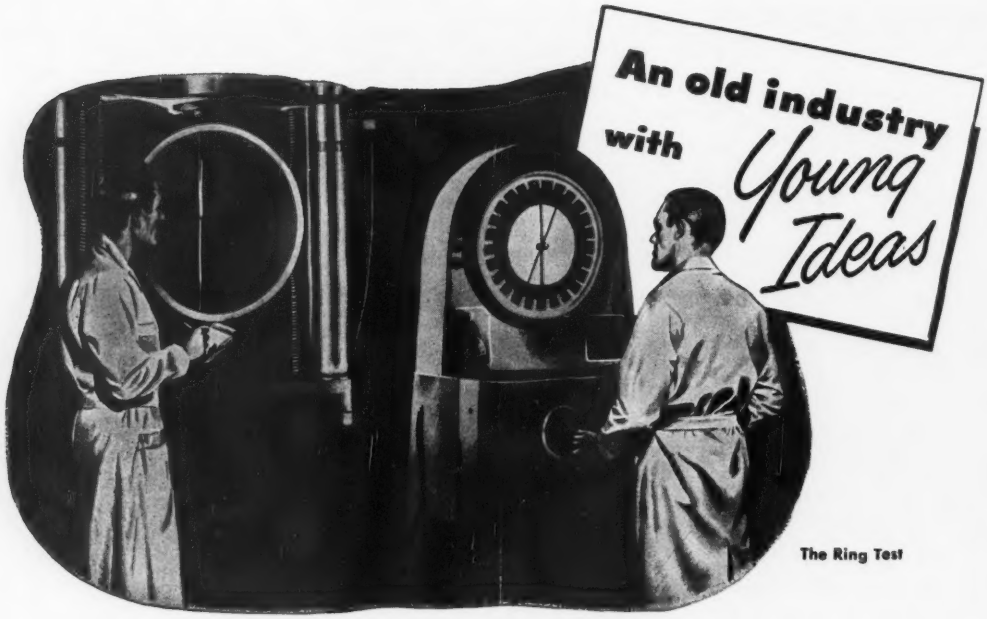
QUALITY ARMA PRECISION INSTRUMENT

34 YEARS OF LEADERSHIP IN INSTRUMENTATION



The Ring Test

The ring test, shown above, is a scientific method for determining the modulus of rupture of pipe. It is not a required acceptance test but one of the additional tests made by cast iron pipe manufacturers to ensure that the quality of the pipe meets or exceeds standard specifications.

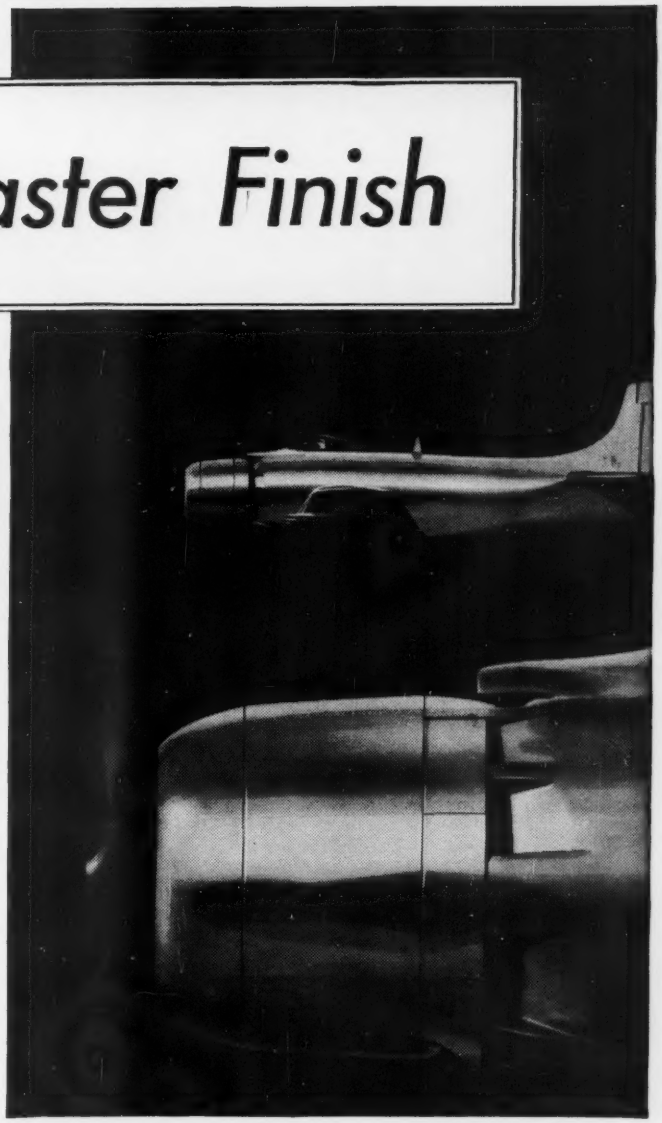
A ring, cut from random pipe, is subjected to progressively increased crushing load until failure occurs. Standard 6-inch cast iron pipe, for example, withstands a crushing weight of more than 14,000 lbs. *per foot*. Such pipe meets severe service requirements with an ample margin of safety.

Scientific progress in the laboratories of our members has resulted in higher attainable standards of quality in the production processes. By metallurgical controls and tests of materials, cast iron pipe is produced today with precise knowledge of the physical characteristics of the iron before it is poured into the mold. Constant control of cupola operation is maintained by metal analysis. Rigid tests of the finished product, both acceptance tests and routine tests, complete the quality control cycle. But with all the remarkable improvements in cast iron pipe production, we do not forget the achievements of the early pipe founders as evidenced by the photograph below of cast iron pipe installed in 1664 to supply the town and fountains of Versailles, France and still in service. Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction. Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3, Illinois.

Section of 285-year-old cast iron water main still serving the town and fountains of Versailles, France.

CAST IRON PIPE SERVES FOR CENTURIES

No Faster Finish



PROBLEM . . .

. . . finishes for aircraft and other military needs which can be applied fast, dry fast without baking, and stand up under severe service conditions.

SOLUTION . . .

. . . hot-spray lacquers now made by many companies from Hercules® nitrocellulose. These new lacquers, thinned by heat rather than solvents, permit more actual lacquer to pass through the spray gun. Now, one hot coat frequently does the job where two coats had been used.

COLLEGE MEN . . .

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry . . .

. . . insecticides, adhesives, soaps, detergents, plastics, paint, varnish, lacquer, textiles, paper, rubber, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products, and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY Wilmington 99, Delaware
Sales Offices in Principal Cities

Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

Thus, Worthington, a major producer of equipment for public works, industry and farm, brings the fruits of American technical genius to the strange places of the world.

And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

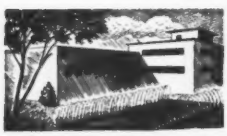
Such diversification builds *stability* . . . makes Worthington, 112 years old, a strong link in the chain of American business.

Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Harrison, New Jersey.

WORTHINGTON

The Sign of Value Around the World

1.14

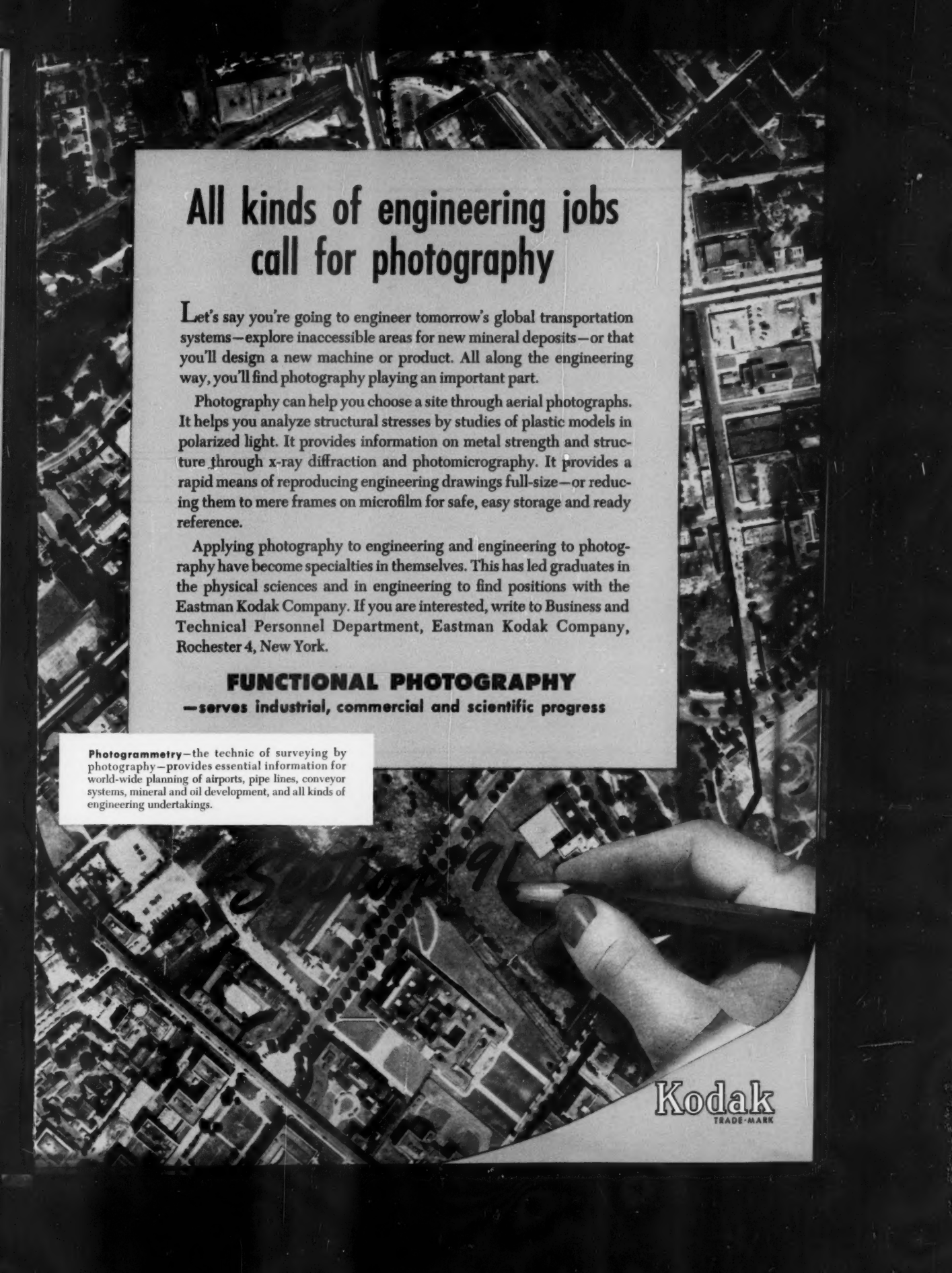


Good Water and Sanitation—engines pumps · water treatment · comminutors air compressors · air tools

Lower-Cost Manufacturing—pumps compressors · steam turbines · motors power transmission · air conditioning

Petroleum Products—compressors engines · pumps · chilling equipment refrigeration · decoking systems

More Abundant Food—compressors fertilizer mixers · air conditioning refrigeration · pumps



All kinds of engineering jobs call for photography

Let's say you're going to engineer tomorrow's global transportation systems—explore inaccessible areas for new mineral deposits—or that you'll design a new machine or product. All along the engineering way, you'll find photography playing an important part.

Photography can help you choose a site through aerial photographs. It helps you analyze structural stresses by studies of plastic models in polarized light. It provides information on metal strength and structure through x-ray diffraction and photomicrography. It provides a rapid means of reproducing engineering drawings full-size—or reducing them to mere frames on microfilm for safe, easy storage and ready reference.

Applying photography to engineering and engineering to photography have become specialties in themselves. This has led graduates in the physical sciences and in engineering to find positions with the Eastman Kodak Company. If you are interested, write to Business and Technical Personnel Department, Eastman Kodak Company, Rochester 4, New York.

FUNCTIONAL PHOTOGRAPHY

—serves industrial, commercial and scientific progress

Photogrammetry—the technic of surveying by photography—provides essential information for world-wide planning of airports, pipe lines, conveyor systems, mineral and oil development, and all kinds of engineering undertakings.

Kodak

TRADE-MARK

WE ASKED GRADUATES TEN YEARS OUT OF COLLEGE:

WHAT WOULD YOU SUGGEST TO MEN NOW PLANNING THEIR CAREERS?

This advertisement is another in a series written by G-E employees who graduated ten years ago—long enough to have gained perspective, but not too long to have forgotten the details of their coming with the Company. These graduates were sent a questionnaire which they returned unsigned. The quotes below represent only a sample of the suggestions received. For a free, mimeographed copy of the full list of comments, write to Dept. 221C-6, Schenectady, N. Y.

"The advice should go back to the sophomore level and it would be to take as many fundamental engineering courses as possible instead of specializing in one field during junior and senior years. The specialization will come as a matter of course due to participation in a phase of engineering occupation after graduation."

"Obtain working experience in all the jobs you think you know nothing about and avoid your primary interest the first year out of college. Ignore geographic location when selecting a job. Even Schenectady is an enjoyable place to live when you've been there long enough to know how to appreciate it. Respect and admire your boss or change bosses."

"Too many of today's graduates are hypnotized by the glamor fields of rockets, jets, etc., whereas they are overlooking good opportunities in the old standard lines."

"Come with G.E., take advantage of opportunity to find field of most interest and possible reward. Don't jump to any foregone conclusions, and don't hurry to find a 'permanent' job."

"This is for freshmen . . . Go to a school that will give you an excellent background in fundamentals of physics, math, mechanics, and materials. Spend at least 25 to 30% of your time in the study of humanities. Forget about machine shop and drawing courses and practical application. Get your practical experience eventually from a company. In a few years you will be worth 10 times more to them and yourself than the so-called practical student."

"Be thoroughly grounded in engineering fundamentals. Experiment in your likes and dislikes by trying several jobs. Work for a company that helps you do this."

"I think the General Electric Test Engineering Program is the ideal employment for the graduate engineer. He should spend the full time on Test with many assignments to obtain the background that will be of utmost value to him."

"Don't specialize too much. Get your fill of math, physics, and so-called liberal arts."

"Don't be afraid to change either training or vocation if you find you don't like it."

"Get a line of work in which you are sincerely interested; it should be a pleasure to get up and go to work in the morning."

"It is a rare thing, one to be cherished as a golden opportunity, to be able to move around on rotation, look over the best facilities and opportunities of a company and thereby be able to make a much more considered choice of where, finally, to work. These things are all possible on the G-E Test Course."

"The most pleasant life seems to be in the sales end of the business. This is what I would tell the college men to strive for if he is fitted for sales work."

"If you don't find your work interesting after five years or rewarded with responsibility and money after 10 years—quit."

"I have worked with hundreds of young fellows since I was on the Test program. Only a few of them knew exactly what they wanted a year or even two years after graduation. One advantage of working with a large company is that it gives them an opportunity to observe a broad field of activities—everything from betatrons to garbage disposers—locomotives to guided missiles. The most important thing in selecting a job is choosing one that will keep the individuals happy, contented and satisfied."

"Get with the company that offers the best training program—the longer the better."

"G-E Test is the best way to spend first 2 years after school—particularly if the graduate is undecided as to his field."

You can put your confidence in—

GENERAL ELECTRIC

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